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Intrinsic Motivation and Engagement as "Active Ingredients" in Garden-Based Education: Examining Models and Measures Derived From Self-Determination Theory

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Building on self-determination theory, this study presents a model of intrinsic motivation and engagement as "active ingredients" in garden-based education. The model was used to create reliable and valid measures of key constructs, and to guide the empirical exploration of motivational processes in garden-based learning. Teacher- and student-reports of garden engagement, administered to 310 middle school students, demonstrated multidimensional structures, good measurement properties, convergent validity, and the expected correlations with self-perceptions in the garden, garden learning, achievement, and engagement in science and school. Exploratory path analyses, calculated using multiple regression, provided initial support for the self-determination model of motivation: students' perceived autonomy, competence, and intrinsic motivation uniquely predicted their engagement in the garden, which in turn, predicted learning in the gardens and achievement in school.

Keywords *engagement, garden-based education, intrinsic motivation, middle school, school gardens, sustainability education*

School gardens are flourishing. In the United States, they number in the tens of thousands, with 4,000 in California alone (California Department of Education, 2010). Goals for school gardens are as unique as the schools themselves, but in general they target four student outcomes: a) science learning and school achievement; b) ecological and environmental awareness and responsible behaviors; such as recycling and composting; d) knowledge about food systems

1. The Learning-Gardens Educational Assessment Group (or *LEAG*) is an interdisciplinary group of faculty and students from the Department of Psychology and the Graduate School of Education at Portland State University and the leadership of Lane Middle School of Portland Public Schools organized around a garden-based education program, the Learning Gardens Laboratory (LGLab). LEAG faculty: Ellen Skinner, Thomas Kindermann, Dae Yeop Kim, Dilafruz Williams (co-founder of the Learning Gardens Laboratory), Pramod Parajuli (co-founder), Karl Logan (Principal, Lane Middle School), Terri Sing (Asst. Principal), Heather Burns (Coordinator of the LGLab), and Weston Miller. *LEAG* students: Lorraine Escribano, Una Chi, Jennifer Pitzer, Amy Lacey, Shawn Mehess, Justin Vollet, Price Johnson, Heather Brule, Shannon Stone, Hyuny Clark-Shim, and Jennifer Wood.

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and nutrition, and healthy eating, especially consumption of fresh fruits and vegetables; and d) positive youth development (Ratcliffe, Goldberg, Rogers, & Merrigan, 2010).

Evidence about the beneficial effects of garden programs comes from qualitative and quantitative research and case studies from multiple disciplines (for reviews, see Blair, 2009; Ozer, 2007; Robinson-O'Brien, Story, & Heim, 2009; Ratcliffe et al., 2010). However, only a few studies have examined the effects of garden-based education on student achievement. An important early study involved more than 400 students and 250 teachers in 40 schools who were designated as using the Environment as an Integrating Context (EIC) (Lieberman & Hoody, 1998). Results indicated that EIC students showed: a) higher levels of interest, enthusiasm, and engagement in learning activities; b) better attendance and fewer disciplinary referrals; and c) higher achievement, as measured by standardized test scores and GPAs. These findings suggested that using the outdoors as a vehicle for instruction sparks students' enthusiasm and interest in academic activities, which may in turn promote their learning in school.

Since that time, four quantitative studies, focusing specifically on school gardens and using comparisons between pre- and post-test or intervention and control groups, have revealed modest effects of garden programs on science learning and achievement, measured by directly observing science skills (Mabie & Baker, 1996), or by tests of science knowledge (Klemmer, Waliczek, & Zajicek, 2005a; Smith & Motsenbocker, 2005) or knowledge and attitudes toward science and school (Dirks & Orvis, 2005). Although this small body of research hints at the promise of garden-based education for enhancing achievement, none of these studies attempted to identify the "active ingredients" in effective programs, that is, none of them directly examined the processes through which garden-based programs have an impact on achievement. An important next step in quantitative research is to identify and assess the essential elements of garden-based programs and to examine whether they actually predict science learning and school achievement as well as other important outcomes.

In service of these next steps, this article had two goals. The first was to present a theoretical model of motivation, derived from Self-Determination Theory (SDT) (Connell & Wellborn, 1991; Deci & Ryan, 1985, 2000), as a possible explanation for why garden-based education influences achievement. This model places student *engagement with academic work* at the core of program effects. Engagement with academic work is defined as constructive, enthusiastic, willing, emotionally positive, cognitively focused participation in learning activities (Connell & Wellborn, 1991; Skinner & Pitzer, in press; Skinner, Kindermann, & Furrer, 2009; Skinner, Kindermann, Connell, & Wellburn, 2009). Several decades of research have demonstrated that students' engagement predicts their learning, grades, achievement, retention, and graduation (for reviews, see Fredricks, Blumenfeld, & Paris, 2004; Furlong & Christenson, 2008; Jimerson, Campos, & Grief, 2003; National Research Council (NRC), 2004).

Unfortunately, however, no measures of student engagement in garden programs have been published to date. Hence, the second goal of this study was to construct a set of brief quantitative indicators of student engagement in garden-based activities, and to examine whether they showed satisfactory measurement properties, theoretically-based multidimensional structures, convergent validity, and the expected pattern of correlations with garden learning and school achievement, on the one hand, and with other important program outcomes and antecedents, on the other. Item sets from current multi-dimensional teacher- and student-reports of engagement (Skinner, Kindermann, & Furrer, 2009) were adapted for use in garden-based measures.

SELF-DETERMINATION THEORY AND MOTIVATIONAL DEVELOPMENT

The current study was guided by Self-Determination Theory (SDT) (Connell & Wellborn, 1991; Deci & Ryan, 1985, 2000), a motivational theory rooted in organismic metatheories of intrinsic motivation, that integrates multiple personal and social factors that shape student engagement and positive development. The SDT motivational model (see Figure 1) holds that schools can either support or undermine children's fundamental psychological needs, which include the need for relatedness (to feel they are welcome and belong), competence (to feel they are efficacious), and autonomy (to feel self-determined in their learning). These experiences, as crystallized in students' self-perceptions, are the proximal predictors of the quality of students' engagement with learning activities and their resilience in the face of challenges and setbacks, which contribute to their learning and long-term achievement. Strong empirical support has been found for each link in the SDT model: Research confirms that both student self-perceptions and teacher motivational support shape classroom engagement, as described below.

Self-Perceptions Predict Engagement

The self-system processes of competence, relatedness, and autonomy have been found to predict students' engagement in academic work. *Competence*, or perceived control, is perhaps the most frequently studied academic self-perception (Wigfield, Eccles, Schiefele, Rouser, & Davis-Kean,

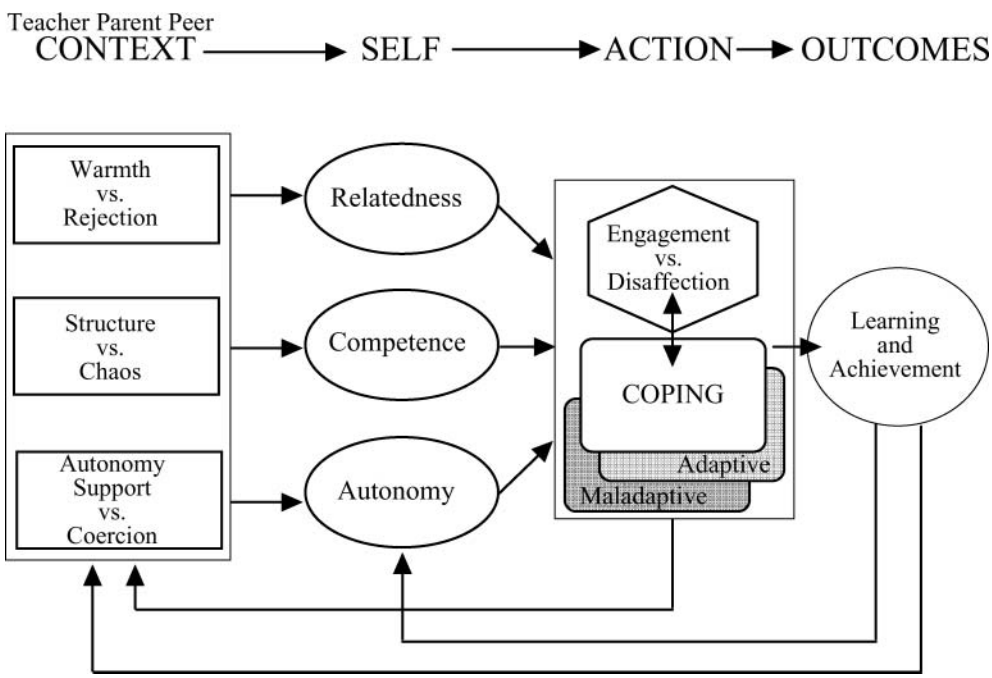

FIGURE 1 The overall self-determination model of motivational development.

2006); decades of research have shown that perceptions of self-efficacy, ability, academic competence, and control are robust predictors of school engagement, learning, academic performance, and achievement (Bandura, 1997; Dweck, 1999; Skinner, 1995). Studies also find links between a sense of *relatedness* or belonging in school and multiple indicators of motivation and adjustment (e.g., Furrer & Skinner, 2003; Goodenow, 1993; Roeser et al., 1996; Ryan, Siller, & Lynch, 1994). Finally, research shows that students with a greater sense of *autonomy* in school also achieve better outcomes such as classroom engagement, enjoyment, persistence, and learning (e.g., Hardre & Reeve, 2003; Patrick, Skinner, & Connell, 1993; Vallerand, Fortier, & Guay, 1997).

Teachers Shape Engagement

Teachers, through the quality of interactions with students, have the ability to shape motivation and engagement in the classroom (Hamre & Pianta, 2001; Murray & Greenberg, 2000; Pianta, 1999; Ryan & Stiller, 1991; Stipek, 2002; Wentzel, 1998; Wigfield et al., 2006). Early work showed that properly structured classrooms promote student motivation (e.g., Ames & Ames, 1985; Rosenholtz & Wilson, 1980). Subsequently, the quality of student-teacher relationships, in the form of caring supportive alliances, has been emphasized as a key predictor of academic engagement, effort, and achievement expectancies (Wentzel, 1997, 1998). Recently, autonomy supportive instruction (giving choices, making learning relevant) has also been linked to engagement (Reeve, Jang, Carrell, Jeon, & Barch, 2004). SDT focuses on all three facets of teacher support: warmth, structure, and autonomy support, each of which has been shown to contribute to students' positive self-perceptions and classroom engagement (Jang, Reeve, & Deci, 2010; Skinner & Belmont, 1993).

ENGAGEMENT IN GARDEN-BASED EDUCATION

We adapted the SDT motivational model, focused on engagement, for use in explaining the effects of garden-based education on student achievement and positive development. The central idea is that the defining features of garden-based programs, which offer holistic, integrated, hands-on, project-based, cooperative, experiential learning activities, are intrinsically motivating and have the potential to meet fundamental needs of children and youth, thereby fostering engagement. The need for *relatedness* can be met by cooperation with classmates, teachers, and master gardeners on a project highly valued by the entire "village." The need for *competence* may be met by experiences that problem-solving, effort, and persistence pay off in tangible outcomes. Most important, gardening introduces activities that are authentic and meaningful, potentially instilling pride and ownership. This supports *autonomy*, a need that is increasingly important and increasingly undermined by schooling as students approach adolescence (Eccles et al., 1993). Garden-based education could enhance student constructive engagement by supporting students' experiences of themselves as connected and related to the garden, competent to carry out science and gardening activities, and autonomous in their sense of purpose and ownership for the garden.

In fact, one reason principals and teachers are so enthusiastic about garden-based education is that such programs seem to capture students' interest and energize their learning. Qualitative studies report students' delight, enthusiasm, and vigorous participation in gardening activities (e.g., Thorp, 2006). If garden-based education can promote student engagement in the gardens,

such programs may become a gateway to increased engagement in science class and in school more generally, contributing to students' academic success. Hence, we predicted that both teacher and student reports of engagement in the garden would be positively and significantly correlated with student self-perceptions in the garden, engagement in science and school more generally, their academic self-perceptions of relatedness, competence, autonomy, and intrinsic motivation, garden learning, and school achievement. Moreover, we relied on path analyses of the garden-based constructs to explore the process model suggested by SDT, in which self-perceptions of competence, autonomy, and intrinsic motivation predict engagement in the gardens, and engagement in turn predicts garden learning and school achievement.

MEASURING STUDENT ENGAGEMENT IN GARDEN-BASED EDUCATIONAL ACTIVITIES

At the center of SDT's motivational model (see Figure 1) is *engagement*. Conceptual and empirical work has shown that engagement is a multidimensional construct, including both behavioral and emotional components (Connell & Wellborn, 1991; Fredricks et al., 2004; Skinner, Kindermann, & Furrer, 2009; Skinner, Kindermann, Connell, & Wellborn, 2009). Behavioral engagement entails exertion of effort, focused attention, persistence, and hard work on academic activities; emotional engagement refers to the experience of energized emotions, such as enjoyment, fun, interest, and enthusiasm, while learning. The opposite of engagement is *disaffection*, which refers to disengagement and alienation from academic work, and also includes behavioral and emotional features. Behavioral disaffection involves passivity, inattention, lack of effort and persistence; emotional disaffection includes boredom, frustration, and dissatisfaction during academic activities.

To create measures of engagement in garden-based activities, we relied on items from current teacher- and student-reports of classroom engagement (Skinner, Kindermann, & Furrer , 2009), which we adapted based on observations of the garden program and open-ended interviews with students and teachers. In order to ensure that the measures of engagement in the gardens covered the same conceptual ground as the parent measures from which they were adapted, items were included that tapped both engagement and disaffection, and their behavioral and emotional features. Hence, we expected the item sets to show multi-dimensional structures similar to those found in the parent measures (Skinner, Kindermann, & Furrer, 2009). At the same time, because the brief garden-based assessments had considerably fewer items than their parent measures, we realized that we might not be able to detect all of the multi-dimensionality captured by the longer scales. Most important, since we were interested in creating markers of overall engagement, we expected that the correlations between dimensions would be high enough that items from different dimensions could be combined (with the disaffection items reverse coded) to form internally consistent aggregate indicators of engagement.

Above all, we were interested in assessing the validity of the indicators, especially their convergent validity, as reflected in the correlation between the two independent measures of student engagement (i.e., teacher and student reports). We expected a positive and significant correlation, showing that reporters agree on the behaviors and emotions that students show in the garden, although, as in other studies that included multiple measures of engagement, we expected the correlations between reporters to be modest, since each reporter has his or her own

perspective, with students typically reporting that they work harder than is noted by teachers, and teachers typically viewing students as more emotionally engaged than students report themselves to be (Skinner, Kindermann, & Furrer, 2009).

SUMMARY

Given the popularity of garden-based programs, it is important to identify and measure their "active ingredients" and to examine whether these processes actually predict garden learning and school achievement. In this paper, we presented a motivational explanation of the impact of garden-based education, based on SDT, with student *engagement in academic work* hypothesized to be at the core of program effects. In this study, our goals were to construct a set of brief quantitative indicators of student engagement in garden-based learning activities that were reliable and valid, and to examine whether they showed the predicted process links with student learning in the gardens and school achievement, as well as with other important potential antecedents and outcomes.

METHODS

Setting and Sample

As motivational researchers, we were recruited by the founders of The Learning Gardens Laboratory, a garden-based education program carried out in cooperation with a middle school serving students from largely minority, low-income, and immigrant families. This program operates on four acres across from the middle school and is staffed by education graduate students with support from university faculty and horticultural experts. Table 1 includes a description of the program.

Participants were 310 sixth and seventh grade students ages 11 to 13 from a middle school in the Pacific Northwest, and their six Science teachers. 55% of the school's students were minorities (8% African American, 24% Latina/o, 15% Asian, 3% Native American; 4% multiple ethnicities); 41% spoke English as a second language; 19 languages were spoken by students. 75% of students qualified for free or reduced lunch.

Design and Measures

Data were collected in spring of one school year. For survey measures, respondents used a five-point rating scale from not at all true (1) to very true (5). Scale scores were created by reverse coding negative items and averaging them with positive items. Complete item sets for the garden-based assessments appear in Tables 2 and 3, and in the Appendix.

Student engagement and disaffection in the garden. Measures of engagement and disaffection in the garden were adapted from the Classroom Engagement measure of students' participation in academic activities, which comprises four dimensions: behavioral engagement, emotional engagement, behavioral disaffection, and emotional disaffection (Skinner, Kindermann, & Furrer, 2009). Teacher-reports of Classroom Engagement use the stem "In my class, this student . . . " with items tapping four dimensions, for example, behavioral engagement

TABLE 1
Overview of the Elements of the Learning Garden Laboratory

Average dose	• 6th grade: 1.5 hrs per lesson, one time per week, 30 weeks. • 7th grade: 1.5 hrs per lesson, one time per week, 15 weeks.
Conceptual framework	• Multi-level integrative developmental systems Model for Garden-Based Education (Ratcliffe et al., 2010). • Holistic integrated learning tied to the elemental experience of the natural environment and growing things (Thorp, 2006). • Intrinsic motivation as a source of energy and engagement in learning when fundamental needs are met (Deci & Ryan, 1985).
Learning objectives and content	• Coordinated with science classes and grade-based science concepts. • Incorporates math, English, and social studies concepts. • Based in systems thinking, ecological awareness, and an appreciation for multicultural diversity.
Projected outcomes	• Engage students in gardening and science learning, and promote academic motivation, engagement, and resilience. • Improve learning and achievement. • Instill a sense of purpose, belonging, community, self-efficacy, autonomy, and ownership. • Promote ecological awareness and stewardship for the land.
Curricular principles	• *Curricular learning environment*: provide hands-on, project based, place-based education engaging youth in authentic ongoing activities that integrate curricula across disciplines, reinforcing concepts and abstract ideas (Ratcliffe et al., 2010). • *Physical learning environment*: improve quality and diversity of learning environments and safe spaces, including opportunities for visual learning and direct experiences of abstract concepts (Ratcliffe, 2010). • *Social learning environment*: foster caring relationships, provide high expectations and clear feedback, and explain the relevance and importance of activities and rules while soliciting input from students and listening to and respecting their opinions (Deci & Ryan, 1985).
Examples of gardening activities	• Planning activities: Students diagram own 3′ by 4′ garden plot, including types of plants. • Soil preparation activities: Students dig new beds and mix compost. • Planting activities: Students transplant seedlings. • Tending activities: Students water and weed beds. • Harvesting activities: Students pick and wash vegetables. • Preparing and eating activities: Students cook and eat vegetables.

(e.g., "works as hard as he/she can"; Skinner, Kindermann, & Furrer, 2009). For garden-based engagement, teacher-reports used the stem "In the Learning Gardens, this student . . . " with six items designed to tap behavioral engagement (e.g., "works as hard as he/she can"), emotional engagement (e.g., "is enthusiastic"), behavioral disaffection (e.g., "is not really into it"), and emotional disaffection (e.g., "seems bored"). The original measure of Classroom Engagement included 16 teacher-report items (Skinner, Kindermann, & Furrer, 2009), whereas the brief measure of teacher-report Garden-Based Engagement included only six items, so that teachers could complete the assessment for every student.

Student-reports of their own Classroom Engagement use the stem, "In class, I . . . " with items tapping the four dimensions, for example, behavioral engagement (e.g., "try hard to do well";

TABLE 2
Factor Loadings, Inter-Factor Correlation, and Fit Indices for a Confirmatory Factor Analysis of a Two-Factor Model of Teacher-Report of Student Engagement and Disaffection in the Learning Gardens

	Factor loadings	
Items	*Engagement*	*Disaffection*
In the Learning Gardens, this student . . .		
• Gets very involved. (+)	.97	—
• Is enthusiastic. (+)	.96	—
• Works as hard as he/she can. (+)	.95	—
In the gardens, this student . . .		
• Doesn't really like it. (−)	—	.95
• Seems bored. (−)	—	.93
• Is not really into it. (−)	—	.97
Factor inter-correlation		−.74***

Fit indices for confirmatory factor analyses

Model	χ^2, *df, p*	*cmin/df*	*GFI*	*CFI*	*RMSEA*
One-factor model	χ^2 (8) = 717.90, $p < .001$	79.77	.58	.73	.51
Two-factor model	χ^2 (8) = 17.63, $p < .05$	2.20	.98	.99	.06

Note: $N = 310$. ***$p < .001$. Because there were only six engagement items for the teacher report, a four-factor model could not be examined.

Skinner, Kindermann, & Furrer, 2009). Student-reports of their own engagement in the garden were captured using the stem "When I'm in the garden . . . " with ten items tapping behavioral engagement (e.g., "I try hard to do well"), emotional engagement (e.g., "I feel good"), behavioral disaffection (e.g., "my mind wanders"), and emotional disaffection (e.g., "I feel bored"). The original measure of Classroom Engagement included 25 student-report items (Skinner, Kindermann, & Furrer, 2009), whereas the brief measure of student-report Garden-Based Engagement included only ten items, in order to ensure that the measure was not too taxing for students to complete.

Garden learning outcomes. Students responded to six items describing how much they had learned about gardening, the environment, food, and science (e.g., "I learned how to do science–experimenting, measuring, observing, finding out new facts"). All items appear in the Appendix. The internal consistency reliability for this scale was satisfactory (alpha = .88).

Student achievement. Information was taken from students' records about quarterly grades in core subjects (math, science, and social studies). Letter grades were converted to a standard four point GPA scale, with "A" equals 4. The average GPA was 2.74 ($SD = 1.14$).

Perceived competence in the garden. Six student-report items from the Student Perceptions of Control Questionnaire (Skinner, Wellborn, & Connell, 1990) tapping students general expectancies about whether they can achieve success and avoid failure were adapted for use in the domain of gardening (e.g., "I can figure out how to make things grow" and "I don't have the brains to garden," reverse coded). All items appear in the Appendix. The internal consistency reliability for this scale was adequate (alpha = .73).

TABLE 3
Factor Loadings, Inter-Factor Correlations, and Fit Indices for a Confirmatory Factor Analysis of a 4-factor Model of Student-Report of Behavioral and Emotional Engagement and Disaffection in the Learning Gardens

	Factor loadings			
Items	*Behavioral engagement*	*Emotional engagement*	*Behavioral disaffection*	*Emotional disaffection*
When I'm in the garden,				
• I try hard to do well. (+)	.88			
• I listen carefully to our gardening teacher. (+)	.80			
• I feel good. (+)		.89		
Gardening is interesting. (+)		.86		
When I'm in the garden,				
• I can't wait for it to be over. (−)			.89	
• I just act like I'm working. (−)			.60	
• my mind wanders. (−)			.53	
Gardening is boring. (−)				.83
I don't care if I miss gardening class.				.76
I'd rather be doing just about anything else but gardening. (−)				.62
Inter-factor correlations	*Behavioral engagement*	*Emotional engagement*	*Behavioral disaffection*	*Emotional disaffection*
Behavioral engagement				
Emotional engagement	.92***			
Behavioral disaffection	−.61***	−.67***		
Emotional disaffection	−.75***	−.82***	.84***	
Fit indices for confirmatory factor analyses				
Model	*χ^2, df, p*	*cmin/df*	*GFI*	*CFI*	*RMSEA*
One-factor model	χ^2 (35) = 260.59, $p < .001$	7.45	.82	.87	.14
Four-factor model	χ^2 (29) = 68.36, $p < .001$	2.36	.96	.98	.07

Note: $N = 310$. ***$p < .001$.

Intrinsic motivation in the garden. Three student-report items were adapted from the Self-regulatory Styles Questionnaire (Ryan & Connell, 1989) to tap whether students engaged in gardening activities for *intrinsic* reasons, that is, because it is enjoyable (e.g., "Why do I garden? Because it's fun"). All items appear in the Appendix. The internal consistency reliability for this scale was satisfactory (alpha = .88).

Autonomy orientation in the garden. Six student-report items from the Self-Regulatory Styles Questionnaire (Ryan & Connell, 1989) were adapted for use with gardening activities. Three items tapped whether students engaged in gardening activities for *external* reasons, that is, because of rules or fear of punishment (e.g., "Why do I garden? They make us") and three tapped whether students engaged in gardening activities for *identified* reasons, that is, because of a desire to understand and learn (e.g., "Why do I garden? So I can learn important things"). All items appear in the Appendix. An aggregate indicator for autonomy orientation, calculated by reverse

coding the external items and averaging them with the identified items, showed satisfactory internal consistency reliability (alpha = .85).

The remaining scales were adapted from existing assessments with well-established measurement properties and satisfactory internal consistency reliabilities.

Academic Engagement

Teacher-report of student science engagement. Each student's engagement in science class was captured using science teachers' responses to the stem "In science, this student . . . " with six items tapping behavioral engagement (e.g., "works hard"), emotional engagement (e.g., "seems interested"), behavioral disaffection (e.g., "refuses to do anything"), and emotional disaffection (e.g., "does not really care") (Skinner, Kindermann, & Furrer, 2009).

Student-report classroom engagement. Students responded to eight items from the Classroom Engagement measure of students' participation in academic activities in school in general (Skinner, Kindermann, & Furrer, 2009).

Academic Self-Perceptions

Sense of relatedness. Students completed five items regarding their sense of belonging or connectedness to their school (e.g., "I feel like a real part of this school" and "I feel like an outsider at this school," reverse coded; Connell & Wellborn, 1991; Furrer & Skinner, 2003).

Perceived control in the academic domain. Students completed six items from the Control Beliefs scale of Student Perceptions of Control Questionnaire (SPOCQ) (Skinner et al., 1990) (e.g., "I can do well in school if I want to" and "I can't get good grades, no matter what I do," reverse coded).

Intrinsic motivation. The measure of academic intrinsic motivation was composed of two items that tapped whether students engaged in academic activities for intrinsic reasons, that is, because they are enjoyable (e.g., "Why do I do my school work? Because it's fun") (Ryan & Connell, 1989).

Autonomy orientation. The measure of academic autonomy was composed of two items that tapped whether children engaged in activities for *identified* reasons (e.g., "Why do I do my school work? Because doing well in school is important to me") (Ryan & Connell, 1989).

RESULTS

The data were analyzed in four steps. First, the measurement properties of the new assessments of garden-based engagement were analyzed, using confirmatory factor analyses to test their multidimensional structures, Cronbach's alpha to examine their internal consistency reliabilities, and correlations between independent measures to gauge their convergent validity. Second, descriptive statistics and internal consistencies of the other measures were examined. Third, to obtain an overall sense of the plausibility of the larger SDT model, correlations were examined to see whether the measures of garden-based engagement showed the hypothesized connections with

their potential antecedents and consequences. Fourth, to examine the process model, exploratory path analyses, calculated using multiple regression analyses, were conducted on the garden-based constructs.

Garden-Based Engagement: Teacher and Student Reports

Structure of the item sets for engagement and disaffection. Confirmatory factor analyses were used to test the fit between the hypothesized multidimensional structures and the item sets for teacher- and student-reports of engagement and disaffection. Multiple fit indices were used to gauge the model-sample discrepancy, which reflects the difference between the predicted covariances and the sample covariances (Hu & Bentler, 1999; Jackson, Gillaspy, & Purc-Stephenson, 2009): CMIN/DF (more commonly known as χ^2/DF) with a desirable ratio of less than three to one; the Goodness of Fit Index (GFI, a measure of the discrepancy between predicted and observed covariances) with a desirable value greater than .95; the Comparative Fit Index (CFI, a noncentrality-based parameter) with a desirable value greater than .95; and the RMSEA (square root of the average squared amount by which the sample correlations differ from their estimates under the model) with desirable values less then .06.

As expected, single factor models were not a good fit to the data for either teacher-reports (see Table 2) or student-reports (see Table 3). Instead, for the teacher-report items, a two-factor model in which the three engagement items loaded on one factor and the three disaffection items loaded on the other proved to be a good fit with the data (see Table 2). As expected, factor loadings were high, ranging from .93 to.97, and the inter-factor correlation was also high ($-.74$, $p < .001$). It should be noted that, because the brief teacher-report measure had only six items, it was not possible to examine the fit of a four-factor model.

For student-report items, a-four factor model in which items tapping behavioral engagement, emotional engagement, behavioral disaffection, and emotional disaffection loaded on separate factors proved to be a good fit with the data (see Table 3). As expected, factor loadings were satisfactory, ranging from .53 to .89. Inter-factor correlations showed the expected pattern, in which behavioral and emotional dimensions were positively correlated (.92 for behavioral and emotional engagement, and .84 for behavioral and emotional disaffection) and the engagement and disaffection dimensions were negatively correlated ($-.61$ for behavioral engagement and disaffection, and $-.82$ for emotional engagement and disaffection, all ps $< .001$).

Measurement properties of teacher and student reports of engagement and disaffection. The means, standard deviations, and internal consistency reliabilities for the two measures of garden-based engagement are presented in Table 4. As expected, the multiple dimensions of each measure, although distinguishable, were sufficiently correlated with each other that aggregate scores, in which the disaffection items were reverse coded, showed satisfactory inter-item consistencies (.95 for the six-item teacher report and .90 for the 10-item student report). Moreover, the mean levels of the aggregate scores indicated that both students and teachers reported students to be relatively engaged in garden-based learning activities, since both means were above the midpoint of the 5-point scales.

Convergent validity. Of greatest interest was the correlation between the two respondents' reports of student engagement, since a positive and significant correlation between independent assessments of the same construct indicates convergent validity. As shown in Table 4, in the

TABLE 4
Measurement Properties, Descriptive Statistics, and Correlations for Teacher and Student Reports of Student Engagement in the Gardens

	No. of items	*Alpha*	*Mean*	*SD*
Garden engagement				
Teacher report	6	.95	3.78	1.01
Student report	10	.90	3.55	.93

Inter-reporter correlation	*Garden engagement*
Garden engagement	Student-report
Teacher-report	.37 ***

Note: $N = 310$. *Range* = 1 (not at all true) to 5 (totally true).
$^{***}p < .001$.

current study, the correlation between teacher and student reports of student engagement in the garden was indeed positive and significant ($r = .37$, $p < .001$). This correlation is comparable to the modest correlations between teacher and student reports of engagement found in other studies (e.g., Skinner & Belmont, 1993; Skinner, Kindermann, & Furrer, 2009).

Potential Antecedents and Consequences of Garden-Based Engagement

The second set of analyses examined the descriptive statistics for the other measures used in the study, including the means and standard deviations for each measure, and their internal consistency reliabilities calculated using Cronbach's alpha (see Table 5). The measure of students' perceptions of learning in the garden showed satisfactory internal consistency reliability, despite the fact that it combined learning about different topics, including plants, food, the environment, and science.

TABLE 5
Measurement Properties and Descriptive Statistics for Learning in the Garden, Garden Self-Perceptions, Science and Classroom Engagement, and Academic Self-Perceptions

	No. of items	*Alpha*[a]	*Mean*	*SD*
Learning outcomes (student-report)				
Garden learning	6	.88	3.22	1.05
Self-perceptions in the garden (student-report)				
Perceived competence in the garden	6	.73	3.57	.86
Intrinsic motivation in the garden	3	.88	3.35	1.27
Autonomy orientation in the garden	6	.85	3.39	1.02
Academic engagement				
Science engagement (teacher-report)	6	.96	3.81	1.16
Classroom engagement (student-report)	8	.85	3.85	.77
Academic self-perceptions (student-report)				
Sense of relatedness	5	.76	3.51	.89
Perceived competence	6	.69	4.15	.73
Intrinsic motivation	2	.69	2.42	1.18
Autonomy orientation	2	.65	3.71	1.09

[a]or inter-item correlation for scales with only two items.

Adequate internal consistencies were found for students' reports of their self-perceptions in the garden, including their perceived competence, intrinsic motivation, and autonomy orientation (average alpha = .82, range .73–.88).

The two measures of academic engagement, in science class (teacher report) and school in general (student report), also showed satisfactory internal consistencies (average alpha = .91). However, the student report measures of academic self-perceptions showed internal consistencies (or inter-items correlations for constructs measured using only two items) that were marginal. Hence, the correlations involving these measures may be attenuated due to their low reliabilities.

Correlations of Garden Engagement with Proposed Outcomes and Antecedents

The third set of analyses was designed to provide a general overview of garden engagement as part of the "nomological net" suggested by the larger SDT model, by examining whether student and teacher ratings of engagement in the garden showed the hypothesized connections with student garden learning and achievement, as well as with other potential outcomes and antecedents of garden engagement, such as garden self perceptions, engagement in science and school, and academic self-perceptions.

Garden learning and achievement. The correlations between teacher and student ratings of engagement in the garden and student garden learning (student-report) and achievement (GPA) are presented in Table 6. As hypothesized, engagement as rated by both reporters was significantly and positively correlated with both student perceptions of how much they learned in the gardens and students' actual grades in core subjects in school. As might be expected based on common-reporter variance, student-reports of their own engagement were more highly correlated with student-reports of their learning whereas teacher-reports of student engagement were more highly correlated with students' achievement.

Garden self-perceptions. Table 6 also contains the correlations between engagement in the garden and students' perceptions of their competence, autonomy, and intrinsic motivation

TABLE 6
Correlations Between Engagement in the Gardens and Potential Outcomes and Antecedents: Learning, Achievement, and Self-Perceptions

	Engagement in the garden (teacher-report)	*Engagement in the garden (student-report)*
Garden learning (student-report)	.27***	.73***
Achievement		
GPA total	.47***	.25***
Student self-perceptions in the garden (student-report)		
Perceived competence in the garden	.11***	.53***
Intrinsic motivation in the garden	.29***	.84***
Autonomy orientation in the garden	.31***	.82***

Note: $N = 310$.
$^{***}p < .001$.

TABLE 7
Correlations Between Engagement in the Gardens and Potential Outcomes: Classroom Engagement in Science and School, and Academic Self-Perceptions

	Engagement in the garden (teacher-report)	*Engagement in the garden (student-report)*
Academic engagement		
Science engagement (teacher-report)	.70***	.27***
School engagement (student-report)	.34***	.62***
Academic self-perceptions (student-report)		
Sense of relatedness	.18***	.43***
Perceived competence	.30***	.36***
Intrinsic motivation	.16***	.44***
Autonomy orientation	.35***	.56***

$N = 310$.
***$p < .001$.

for gardening activities. As hypothesized, all self-perceptions were positively and significantly correlated with student engagement. Autonomy orientation and intrinsic motivation for gardening activities were most strongly connected to engagement (average $r = .57$ for autonomy and intrinsic motivation), whereas perceived competence in gardening was not as strong a predictor of students' engagement (average $r = .32$).

Engagement in science and school. Correlations between garden engagement and engagement in science class and school are presented in Table 7. As hypothesized, all correlations were positive and significant. Students who were more engaged in the gardens were more likely to be engaged in science and in school in general, just as students who were more disaffected in the gardens were more likely to show disaffection in both science class and school. As might be expected based on common-reporter variance, teacher reports of garden engagement were more highly correlated with teacher reports of science engagement whereas student reports of garden engagement were more highly correlated with student reports of engagement in school in general.

Academic self-perceptions. Table 7 also contains correlations between engagement in the gardens and students' self-perceptions in school, including a sense of relatedness, perceived competence, intrinsic motivation, and autonomy orientation. As hypothesized, and despite the low internal consistencies for some of the measures of academic self-perceptions, all correlations were positive and significant. For both teacher and student ratings of engagement, autonomy orientations seemed to be the self-system process most tightly connected to garden engagement (average $r = .46$) whereas relatedness (average $r = .31$), competence (average $r = .33$), and even intrinsic motivation for school in general (average $r = .30$) were not as closely related.

Process Model of Garden-Based Engagement

The final set of analyses relied on path analyses, calculated using multiple regression analyses, to explore whether the relationships among the garden-based measures was consistent with the

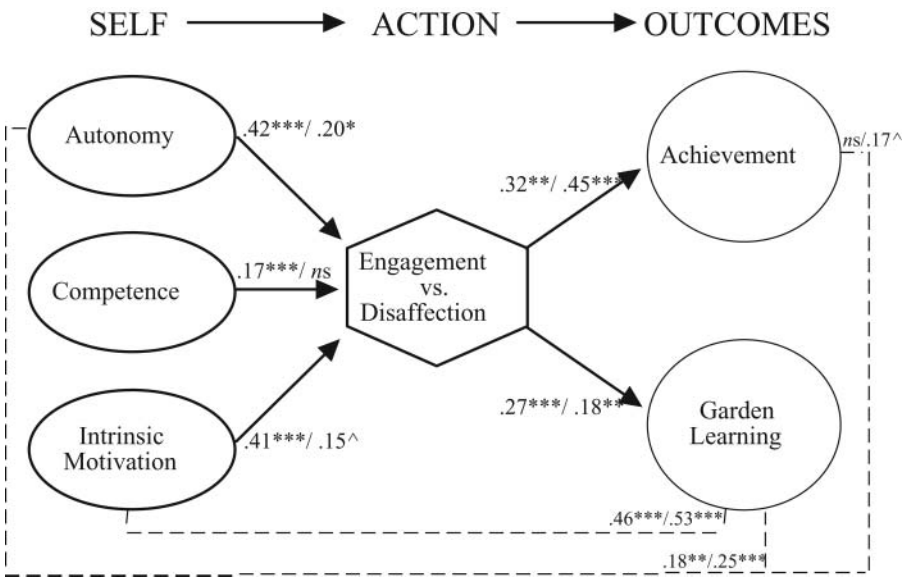

FIGURE 2 Path analyses testing the process model of student engagement in garden-based activities. *Note:* Path analyses were conducted using multiple regression analyses. Standardized coefficients using student-reported engagement are presented before the slash, followed by standardized coefficients using teacher-reported student engagement. The measure of Achievement is overall GPA. Predicted paths are depicted using solid lines; unpredicted paths are depicted using dashed lines. $^{***}p < .001$; $^{**}p < .01$; $^{*}p < .05$; $^{\wedge}p < .10$.

process model of engagement in the garden. The model hypothesized that the three garden-based self-perceptions (competence, autonomy, and intrinsic motivation) would predict garden-based engagement, which would in turn predict garden learning and school achievement. One set of regression analyses was conducted using teacher reports of student engagement and one set using student reports of engagement.

The results for both student and teacher reports of student engagement are depicted in Figure 2. Overall, the path analyses were consistent with the process model. The first set of multiple regressions, which examined the unique effects of the three self-perceptions on garden-based engagement, revealed that both autonomy and intrinsic motivation made significant unique contributions to both student- and teacher-reports of engagement; however, perceived competence was a unique predictor only of student-reports of engagement.

The second set of regressions, which examined whether garden-based engagement predicted learning in the gardens or achievement, over and above the effects of the self-perceptions, revealed that both reporters' ratings of student engagement made unique contributions to both garden learning and overall GPA, although, as could be expected based on common-reporter variance, student-reported engagement was a stronger unique predictor of student-reported learning whereas teacher-reported student engagement was a stronger unique predictor of school achievement. However, the path analyses also revealed that student engagement did not fully mediate the effects of intrinsic motivation and a sense of autonomy on student-reported garden learning; both

showed direct effects, even after controlling for engagement. The direct effects from intrinsic motivation to learning were especially high.

DISCUSSION

The findings from the current study were generally consistent with the motivational explanation of the effects of garden-based education provided by self-determination theory. Newly adapted student and teacher report measures of student engagement in the garden, which included behavioral and emotional engagement and disaffection, both showed the predicted multidimensional structures; at the same time, dimensions were sufficiently inter-correlated to allow the creation of aggregated measures with satisfactory internal consistencies. Importantly, evidence was found for convergent validity, in that the two independent measures of engagement were positively and significantly correlated with each other. Consistent with previous measurement studies (e.g., Skinner, Kindermann, & Furrer, 2009), the correlation between teacher and student reports was modest, perhaps reflecting the fact that students report individualized versions of what they are experiencing whereas teachers likely report comparative evaluations of what students are expressing. Taken together, these findings suggest that these two brief measures of garden engagement may serve as valid and reliable markers of the quality of students' participation in garden-based activities, capturing both on-task behavior and emotional enthusiasm about learning.

The newly adapted measures of students' self-perceptions in the garden, including their perceived competence, intrinsic motivation, and autonomy orientations, also worked well, both in terms of their internal consistency reliabilities and their connections to student and teacher reports of student engagement in the garden. Moreover, analyses examining the connections between engagement in the garden and indicators of garden learning and overall school GPA supported the hypothesized links between motivation and achievement. Both teacher and student reports of garden engagement showed the expected positive relation with students' perceptions of how much they were learning in the garden as well as with students' performance on core academic subjects. Such a pattern of effects should be found consistently if garden engagement, like other forms of classroom engagement, actually contributes to students' learning and academic success (Fredricks et al., 2004).

As predicted by the motivational model, students' engagement in the garden was also connected to their engagement in science class and their overall engagement in school as well as to their academic self-perceptions, including a sense of relatedness to school, perceived competence, intrinsic motivation, and autonomy orientation. It is possible that students' engagement in the garden transfers some of their excitement about learning to science class and to school in general, perhaps by meeting students' fundamental needs for relatedness, competence, and autonomy, as tapped by measures of their academic self-perceptions.

Exploratory path analyses of the garden-based constructs, calculated using multiple regressions, generally supported the process model used to guide the study. As highlighted by SDT, students' intrinsic motivation, and especially their autonomy in the garden, made the strongest unique contributions to both student and teacher reports of garden engagement. At the same time, two sets of findings suggested how the model, which was derived from previous research on general school engagement, could be elaborated to provide a better explanation of the specific effects of garden-based education. First, results from the regression analyses suggested that not all

the self-perceptions are equally important in supporting students' garden engagement. Although perceived competence is typically one of the most important predictors of school engagement (Wigfield et al., 2006), competence in the garden was not a strong unique contributor to garden engagement.

Second, not all the effects of self-perceptions on garden learning were mediated by garden engagement. Both intrinsic motivation and autonomy showed indirect effects on learning and achievement through the pathway of engagement, but they also showed direct effects, especially intrinsic motivation. These direct paths suggest that there may be other mediators besides engagement through which autonomy and intrinsic motivation shape learning in the garden. At the same time, they may also reflect reciprocal effects, in which greater learning in the gardens fosters more intrinsic motivation and a greater sense of autonomy.

Although it would be important to replicate this pattern of findings before it is given too much weight in theory building, one possible implication is that garden-based programs differ from regular schoolwork: Perhaps in the garden, students do not require a high sense of their own capability in order to enthusiastically engage in learning activities; instead their participation is fostered by a sense of the personal importance and inherent enjoyment of the activities themselves. Stated conversely, research shows that, in regular school activities, students who lack self-efficacy are typically more disaffected from learning (e.g., Dweck & Molden, 2005); however, it may be that, in the garden, doubts about one's scholastic abilities are not necessarily a barrier to engagement.

Limitations of the Current Study

Although the pattern of findings from the current study was encouraging, its implications for future research on garden-based education should be considered in light of its limitations. First, in terms of attempting to capture students' engagement in the garden, the study would have been strengthened by the inclusion of observational measures (e.g., Reeve et al., 2004; Skinner, Kindermann, & Furrer, 2009). If student and teacher reports were correlated with observer ratings of engagement, this would provide the strongest evidence of construct validity for the survey measures.

A second limitation of the study was its reliance on student perceptions of learning in the garden. Although students' ratings were internally consistent, a better measure would have been a direct examination of students' knowledge about plants, food, the environment, and science (e.g., Klemmer et al., 2005a). A third limitation follows from the low internal consistencies found for the scales measuring student academic self-perceptions. Scales that utilize more items would produce higher reliabilities, and possibly higher correlations with garden-based constructs. A final limitation is based on the study's design, which involved only one time of measurement. As a result, correlational findings likely reflect not only the effects of the (putative) antecedents on their outcomes, but also reciprocal effects.

Future Research on Student Engagement in Garden-Based Education

Future research on student motivation in garden-based education would do well to map out the other constructs included in the self-determination model of motivation. Especially important

would be students' sense of relatedness or belonging in the garden, and the motivational supports students receive from science teachers or garden educators. Self-determination theory highlights the important role of social partners in meeting psychological needs, arguing that engagement is promoted when teachers foster caring relationships, provide high expectations and clear feedback, and explain the relevance and importance of activities and rules while soliciting input from students and listening to and respecting their opinions (Deci & Ryan, 1985).

Studies that incorporate measures of relatedness and teacher motivational support, along with the other garden-based constructs included in the current study, using a design that includes multiple time points during the school year, would have the potential to test the proposed motivational model more fully, by examining, for example, whether teacher support and student self-perceptions in the garden can predict *changes* in students' garden engagement over the school year as well as changes in engagement in science and school in general. Such studies will be useful in discovering ways in which the SDT model can be improved to provide a better explanation of the effects of garden-based programs.

CONCLUSION

Our goal was to present a model of engagement in garden-based education derived from self-determination theory, and to construct and examine a set of measures to capture constructs the model holds are key to student motivation, learning, and development. Results were encouraging. Assessments of engagement and self-perceptions in the garden worked well and showed the expected pattern of positive and significant correlations with potential academic outcomes such as learning and achievement, and with other important outcomes such as engagement in science and school, and academic self-perceptions. At the same time, path analyses suggested ways to further elaborate the theoretical model for use in future studies. Taken together, findings from this study suggest that self-determination theory, with its focus on intrinsic motivation and human needs for relatedness, competence, and autonomy, can provide a useful foundation for empirical exploration of the motivational impact of garden-based educational programs.

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REFERENCES

Ames, C., & Ames, R. (1985). *Research on motivation in education: Vol. 2. The classroom milieu*. San Diego, CA: Academic Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: W. H. Freeman.

Blair, D. (2009). The child in the garden: An evaluative review of the benefits of school gardening. *Journal of Environmental Education*, *40*(2), 15–38.

California Department of Education. (2010). *School garden program overview: A healthy nutrition environment: Linking education, activity, and food through school gardens*. Retrieved from http://www.cde.ca.gov/ls/nu/he/gardenoverview.asp

Connell, J. P., & Wellborn, J. G. (1991). Competence, autonomy and relatedness: A motivational analysis of self-system processes. In M. Gunnar & L. A. Sroufe (Eds.), *Minnesota Symposium on Child Psychology: Vol. 23. Self processes in development* (pp. 43–77). Chicago, IL: University of Chicago Press.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum Press.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, *11*, 227–268.

Dirks, A. E., & Orvis, K. (2005). An evaluation of the Junior Master Gardener program in third grade classrooms. *HortTechnology*, *15*, 443–447.

Dweck, C. S. (1999). *Self-theories: Their role in motivation, personality, and development.* Philadelphia, PA: Psychology Press.

Dweck, C. S., & Molden, D. C. (2005). Self-theories: Their impact on competence motivation and acquisition. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 12–140). New York, NY: Guilford.

Eccles, J. S., Midgley, C., Wigfield, A., Buchanan, C. M., Reuman, D., Flanagan, C., & McIver, D. (1993). Development during adolescence: The impact of stage-environment fit on adolescents' experiences in schools and families. *American Psychologist*, *48*, 90–101.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1) 59–109.

Furlong, M. J., & Christenson, S. L. (2008). Engaging students at school with learning: A relevant construct for *all* students. *Psychology in the Schools*, *45*, 365–368.

Furrer, C., & Skinner, E. (2003). Sense of relatedness as a factor in children's academic engagement and performance. *Journal of Educational Psychology*, *95*, 148–162.

Goodenow, C. (1993). Classroom belonging among early adolescent students: Relationships to motivation and achievement. *Journal of Early Adolescence*, *13*, 21–43.

Hardre, P. L., & Reeve, J. (2003). A motivational model of students' intentions to persist in, versus drop out of, high school. *Journal of Educational Psychology*, *95*, 347–356.

Hu, L., & Bentler, P. (1999). Cutoff criteria for fit indexes in covariance structural analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*, 1–55.

Jackson, D. L., Gillaspy, J. A., Jr., Purc-Stephenson, R. (2009). Reporting practices in confirmatory factor analysis: An overview and some recommendations. *Psychological Methods*, *14*, 6–23.

Jang, H., Reeve, J., & Deci, E. L. (2010). Engaging students in learning activities: It is not autonomy support or structure but autonomy support and structure. *Journal of Educational Psychology*, *102*, 588–600.

Jimerson, S. J., Campos, E., & Greif, J. L. (2003). Towards an understanding of definitions and measures of school engagement and related terms. *The California School Psychologist*, *8*, 7–27.

Klemmer, C. D., Waliczek, T. M., & Zajicek, J. M. (2005a). Development of a science achievement evaluation instrument for a school garden program. *HortTechnology*, *15*, 433–438.

Klemmer, C. D., Waliczek, T. M., & Zajicek, J. M. (2005b). Growing minds: The effect of a school gardening program on the science achievement of elementary students. *HortTechnology*, *15*, 448–452.

Lieberman, G., & Hoody, L. (1998). *Closing the achievement gap: Using the environment as an integrating context for learning*. San Diego, CA: State Education and Environment Roundtable (SEER).

Mabie, R., & Baker, M. (1996). A comparison of experiential instructional strategies upon the science process skills of urban elementary students. *Journal of Agricultural Education*, *37*(2), 1–7.

Murray, C., & Greenberg, M. T. (2000). Children's relationship with teachers and bonds with school. *Journal of School Psychology*, *38*, 423–445.

National Research Council. (2004). *Engaging schools: Fostering high school students' motivation to learn*. Washington, DC: National Academies Press.

Ozer, E. (2007). The effects of school gardens on students and schools: Conceptualizations and considerations for maximizing healthy development. *Health Education and Behavior*, *34*, 846–863.

Patrick, B. C., Skinner, E. A., & Connell, J. P. (1993). What motivates children's behavior and emotion? The joint effects of perceived control and autonomy in the academic domain. *Journal of Personality and Social Psychology*, *65*, 781–791.

Pianta, R. C. (1999). *Enhancing relationships between children and teachers*. Washington, DC: American Psychologist Association.

Ratcliffe, M. M., Goldberg, J., Rogers, B., & Merrigan, K. (2010). A model of garden-based education in school settings: Development of a conceptual framework to improve children's academic achievement, ecoliteracy, health and wellness while enhancing schools, communities, and bioregions (Unpublished manuscript). Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA.

Reeve, J., Jang, H., Carrell, D., Jeon, S., & Barch, J. (2004). Enhancing students' engagement by increasing teachers' autonomy support. *Motivation and Emotion*, *28*, 147–169.

Robinson-O'Brien, R., Story, M., & Heim, S. (2009). Impact of garden-based youth nutrition intervention programs: A review. *Journal of the American Dietetic Association*, *109*, 273–280.

Roeser, R. W., Midgley, C., & Urdan, T. C. (1996). Perceptions of the school psychological environment and early adolescents' psychological and behavioral functioning in school: The mediating role of goals and belonging. *Journal of Educational Psychology*, *88*, 408–422.

Rosenholtz, S. J., & Wilson, B. (1980). The effect of classroom structure on shared perceptions of ability. *American Educational Research Journal*, *17*(1), 75–82.

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology*, *57*, 749–761.

Ryan, R. M., & Stiller, J. (1991). The social contexts of internalization: Parent and teacher influences on autonomy, motivation, and learning. In P. R. Pintrich & M. L. Maehr (Eds.), *Advances in motivation and achievement: Vol. 7, Goals and self-regulatory processes* (pp. 115–149). Greenwich, CT: JAI Press.

Ryan, R. M., Stiller, J. D., & Lynch, J. H. (1994). Representations and relationships to teachers, parents, and friends as predictors of academic motivation and self-esteem. *Journal of Early Adolescence*, *14*, 226–249.

Skinner, E. A. (1995). *Perceived control, motivation, and coping*. Newbury Park, CA: Sage Publications.

Skinner, E. A., & Belmont, M. J. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of Educational Psychology*, *85*, 571–581.

Skinner, E. A., Kindermann, T. A., Connell, J. P., & Wellborn, J. G. (2009). Engagement as an organizational construct in the dynamics of motivational development. In K. Wentzel & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 223–245). Mawah, NJ: Erlbaum.

Skinner, E. A., Kindermann, T. A., & Furrer, C. (2009). A motivational perspective on engagement and disaffection: Conceptualization and assessment of children's behavioral and emotional participation in academic activities in the classroom. *Educational and Psychological Measurement*, *69*, 493–525.

Skinner, E. A., & Pitzer, J. (in press). Developmental dynamics of engagement, coping, and everyday resilience. In S. Christenson, A. Reschly, & C. Wylie (Eds.), *The Handbook of Research on Student Engagement*. New York, NY: Springer Science.

Skinner, E. A., Wellborn, J. G., & Connell, J. P. (1990). What it takes to do well in school and whether I've got it: The role of perceived control in children's engagement and school achievement. *Journal of Educational Psychology*, *82*, 22–32.

Smith, L. L., & Motsenbocker, C. E. (2005). Impact of hands-on science through school gardening in Louisiana public elementary schools. *HortTechnology*, *15*, 439–443.

Stipek, D. J. (2002). Good instruction is motivating. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 309–332). San Diego, CA: Academic Press.

Thorp, L. G. (2006). *The pull of the earth: Participatory ethnography in the school garden*. New York, NY: Rowman & Littlefield.

Vallerand, R. J., Fortier, M. S., & Guay, F. (1997). Self-determination and persistence in a real-life setting: Toward a motivational model of high school dropout. *Journal of Personality and Social Psychology*, *72*, 1161–1176.

Wentzel, K. R. (1997). Student motivation in middle school: The role of perceived pedagogical caring. *Journal of Educational Psychology*, *89*, 411–419.

Wentzel, K. R. (1998). Social relationships and motivation in middle school: The role of parents, teachers, and peers. *Journal of Educational Psychology*, *90*, 202–209.

Wigfield, A., Eccles, J. S., Schiefele, U., Roeser, R., & Davis-Kean, P. (2006). Development of achievement motivation. In W. Damon (Series Ed.) & N. Eisenberg (Volume Ed.), *Handbook of child psychology, Social, emotional, and personality development* (6th ed., vol. 3, pp. 933–1002). New York, NY: Wiley.

APPENDIX—STUDENT SURVEY: LEARNING-GARDENS EDUCATIONAL ASSESSMENT PACKAGE

Learning in the Gardens

What I learned in the garden:

- I learned how I can treat the environment better. (+)
- I learned how plants grow. (+)
- I learned I can make a garden grow at home. (+)
- I learned about things I like to eat that I did not like before. (+)
- I learned what other people from other cultures grow and eat in their gardens. (+)
- I learned how to do science– experimenting, measuring, observing, finding out new facts. (+)

Competence (Self-Efficacy) in the Gardens

Adapted from Skinner, Connell, & Wellborn, 1990

- I am pretty good at gardening. (+)
- I know a lot about gardening. (+)
- I can figure out how to make things grow. (+)
- I don't have the brains to garden. (−)
- I am not very good at gardening. (−)
- Gardening is too hard for me. (−)

Intrinsic Motivation in the Gardens

Adapted from Ryan & Connell, 1989

Why do I garden?

- I enjoy it.
- It's fun.
- It's cool to see things grow.

Autonomy-Autonomous Self-Regulation in the Gardens

Adapted from Ryan & Connell, 1989

Why do I garden?

- So I can learn important things. (+)
- Because I want to treat the environment better. (+)
- It is important to me. (+)
- They make us. (−)
- Our teacher said we had to; otherwise I probably would not. (−)
- That's the rule. (−)