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Effects of the Junior Master Gardener's (JMG) Curriculum on Guatemalan Students' Knowledge Gain and Attitude toward Science

Anna Glenn
University of Maryland Extension, Baltimore County
Cockeysville, MD
USA

Gary Wingenbach
Texas A&M University
College Station, TX
USA

Abstract

We examined the impact of selected Junior Master Gardeners (JMG) lessons on students' science knowledge gain and attitudes toward science. Sixth-grade students (*N* = 84) and teachers (*N* = 11) from two rural schools in Guatemala participated in six weeks of JMG lessons. Students completed pre- and post-science knowledge tests, and pre- and post-science attitude surveys. Teachers also completed surveys to evaluate their perceptions of JMG lessons and their perceived impacts those lessons had on students' science learning and attitudes.

Results showed students' science knowledge significantly increased as a result of their participation in JMG lessons. No change in attitude toward science was observed in the student data; however, data from teachers' surveys indicated teachers perceived JMG lessons were important in stimulating students' desires to learn science and in increasing students' interests in science. The lack of significant change in students' science attitudes may be attributed to low internal reliability scores for the scale; many previous studies conducted in the U.S. indicated participation in 4-H, JMG, and other agricultural education activities facilitated changes in attitudes toward science.

Overall, this study suggests there is great potential for using JMG programs in developing countries. Because of its impact on science education, JMG programs should be accepted as viable tools for international development projects focused on more educated and capable youth populations. Both science knowledge and attitudes toward science are closely associated with economic prosperity and successful livelihoods.

Keywords: Science Education, Junior Master Gardeners, Development Projects

Introduction

A nation's economic prosperity is closely associated with its level of Science, Technology, Engineering, and Mathematics education (STEM), which is essential to developing educated citizens (Osborne, Simon, & Collins, 2003; STEM Education Coalition, 2012). In many developing countries such as Guatemala, the emphasis placed on STEM is undeveloped, underfunded, and overlooked as science classes are especially prone to unequal resource distribution and allocation (Lewin, 2000). Science education is the most expensive area of curriculum because of the nature of the field, which generally requires more qualified teachers, access to costly equipment, curriculum, and technologies, and more hands-on teaching experiences (Lewin, 2000). It is estimated that less than 15% of all Guatemalan classrooms meet nationwide minimum standards (Avivara, 2012; United States Agency for International Development [USAID], 2013).

Youth are the future strength of any nation and the kind of training they receive as children heavily conditions who they will become as adults and what they will accomplish in society (Kinwika & Semana, 2001). In Guatemala, like many other developing countries, rural youth have limited opportunities to obtain a quality education. Often times, the education they receive is irrelevant and casts a negative light on rural agricultural lifestyles, rather than helping them see the strong connection between agriculture and the sciences (Bennell, 2007; Major, 2011). According to the Food and Agriculture Organization (FAO), there is an "urgent need to provide appropriate education, training, and job opportunities" (Sustainable Agriculture and Rural Development [SARD], 2007, p. 2) for rural youth, enabling them to remain and prosper in rural areas and further the advancement of agriculture. However many developing countries fail to recognize the potential of rural youth and to provide programs specifically targeted for them, even though many are already contributing significantly to the survival of the family by means of income and food security (Kinwika & Semana, 2001).

The Junior Master Gardener (JMG) program, a specialized 4-H curriculum, allows youth the opportunity to participate in hands-on agricultural activities and experiments, and provides them with opportunities to experience science learning from a new perspective, which may be more enjoyable and relatable to their lifestyles (Whittlesey, Seagraves, Welsh, & Hall, 2001). Studies on the impacts of JMG, school garden programs, and other agricultural curriculum on young participants showed students involved in these programs were more likely to have higher scientific achievement, increased scientific literacy, heightened passion for continued science learning, higher levels of cognitive thinking, and more positive attitudes toward school in general. These findings may have great impact on the success of youth in developing countries (Boleman & Cummings, 2002; Culin, 2002; Klemmer, Waliczek, & Zajicek, 2005; Ozer, 2007; Pigg, Waliczek, & Zajicek, 2006).

According to Knoblach, Ball, and Allen's (2007) study of teacher perceptions, incorporating agricultural education into the general curriculum of elementary and middle schools brings learning to life by providing experiential learning experiences for children. Experiential learning activities, especially those involving agriculture and nature, captivate children's attention and encourage them to become more interested in what they are learning. They can more readily understand complex scientific issues and have further opportunities to apply what they learned in real-life situations (Kellert, 2002; Knoblach et al., 2007). These hands-on experiences allow students to develop scientific inquiry skills and may produce more positive attitudes toward learning science (Klemmer et al., 2005). By introducing this curriculum into the public education system, students could become more equipped to return to an agrarian lifestyle because of their increased understanding of science or alternatively, they may be encouraged to pursue further education or career opportunities in science which could lead to increased income and job security (Dewitt et al., 2011; Kinwika & Semana, 2001; Major, 2011; SARD, 2007).

Purpose and Objectives

The purpose of this study was to measure effects of lessons in the Junior Master Gardeners' (JMG) curriculum on selected participants in Quetzaltenango, Guatemala. The objectives were to:

1. Evaluate the effect on students' understanding of scientific concepts, when analyzed by pre- and post-participation in selected JMG lessons;
2. Determine the effect on students' attitudes toward science, when analyzed by pre- and post-participation in selected JMG lessons; and,
3. Measure teachers' perceptions of the selected JMG lessons and their effectiveness in teaching scientific concepts and influencing students' perceptions of science.

Methods

Survey research design was used for this study. Survey research designs are often used to assess the outcomes or impacts or a given program or project on its participants (Fraenkel & Wallen, 2009). Two forms of survey research design were used in this study. A pretest-post-test program evaluation was used for student participants and a post-test only program evaluation was used for teacher participants.

The population included sixth-grade students (ages 11 to 17) and teachers from schools in Zunil and Olintepeque, Guatemala. Only students and teachers who participated in JMG activities while the lead researcher was present were eligible to participate in this study. Convenience sampling methods were used to obtain appropriate samples and accurate results as opposed to a pre-defined sample which would have been difficult to obtain because of unreliable school rosters and inconsistent school attendance. All students (N = 84) and teachers (N = 11) who were present when the researcher passed out surveys participated in this study.

The *Assessment of Students' Scientific Knowledge Gain* was a researcher-developed instrument with 25 multiple-choice and fill-in-the-blank questions to assess students' basic scientific and agricultural concepts. For each topic that the lead researcher taught, there were one to two questions targeting knowledge gained on that topic. Answer choices were presented as pictures accompanied by words. If children are allowed to work in a context adapted to their interests (i.e., picture surveys), they are capable of expressing their thoughts and opinions more accurately (Punch, 2002; Rohwer, 1970; Woodhead, 1998). Children in rural Guatemala have low literacy rates so a survey with short pictorial-type questions was appropriate. A sample question was "From the images below, please circle the picture that does not represent part of a plant." The answers were pictures of leaves, stems, roots, flowers, and worms with the words written below each picture.

The *Survey of Students' Attitudes toward Science* section had nine Likert-type statements assessing students' perceptions toward science. This instrument was adapted from DeWitt et al.'s (2011) study of 10 and 11 year olds' aspirations and attitudes toward science. The original instrument measured 15 constructs using more than 62 individual statements; selected statements from the constructs regarding “aspirations in science,” “attitudes toward science,” and “self-concept in science” (DeWitt et al., 2011) were used in this study. All three selected constructs’ scales were tested for reliability using Cronbach’s alpha and were found to be reliable with coefficients of 0.90, 0.86, and 0.84 respectively. Answer choices were presented on a five-point Likert-type scale; responses ranged from an extremely happy/smiling face to an extremely sad/frowning face with the corresponding written descriptions of “*strongly disagree*” to “*strongly agree*” respectively.

Evaluation of the JMG Program was a researcher-developed instrument consisting of 18 Likert-type questions assessing teachers’ perceptions of selected JMG lessons in teaching scientific concepts and changing students’ attitudes toward science. A sample statement was “I believe that JMG lessons were important in enhancing my students’ science learning abilities.” Again, half of the statements were reverse coded to increase the instrument’s reliability (Watson, 1992). Answer choices were on a five-point Likert-type scale with responses ranging from “*strongly disagree*” to “*strongly agree*.”

The research instruments were initially written in English and then translated into Spanish with the help of native Spanish speakers. The research instruments were distributed to both teachers and students two days prior to participation and again two days after all JMG activities had been completed. Students and teachers participated in six weeks of JMG lessons. Data were analyzed using descriptive statistics such as frequencies, medians, modes, ranges, percentiles, standard deviations, correlation tests, and tests of significance.

Results

Student respondents ($N = 84$) included all who participated in six weeks of selected JMG lessons led by the researcher. Forty-six participants were male and 38 were female. Forty-three students participated in JMG lessons in Zunil and 41 students participated in Olintepeque. Teacher respondents ($N = 11$) were present in the classroom for the six weeks of selected JMG lessons. Four participants were male and seven were female. Five teachers from Zunil and six teachers from Olintepeque completed the survey.

On the Likert-scale of 1 to 5, a mean of 1 to 1.50 represented *strongly disagree*, 1.51-2.50 represented *disagree*, 2.51-3.50 represented *no opinion*, 3.51-4.50 represented *agree,* and 4.51-5.00 represented *strongly agree*.

Students’ Scientific Knowledge Gain

Objective one was to evaluate the effect on students’ understanding of scientific concepts as a result of participation in selected JMG lessons, as measured through pre- and post-participation in selected JMG lessons (see Table 1).

Students incorrectly answered eight of the 25 questions more often in the post-test than were observed in the pre-test; however no significant differences were detected. The researchers believe this phenomenon could be explained by lower levels of teacher involvement and assistance during the post-test versus the pre-test and/or by confusing diagrams.

To determine overall knowledge gain of scientific concepts, the researchers summed individuals’ scores for the science knowledge test. The pre-test grand mean score was 13.56 ($SD = 2.55$), and the post-test grand mean score was 15.15 ($SD = 2.63$). A paired samples t-test indicated a significant difference ($t = -7.52$, $\alpha < 0.005$)

with a moderate level correlation (*d* = 0.6) between pre- and post-test science knowledge test scores (Cohen, 1988). Participants gained significant science knowledge as a result of their participation in the JMG lessons.

The researchers believe the significant differences in the summed science knowledge test scores could be attributed to other factors (such as gender or school location) beyond the JMG lessons. Therefore, the researchers conducted ANOVA tests with post-hoc analysis (Bonferroni) to determine if gender or school location affected the pre- or post-test summed scores. Table 2 provides the descriptive statistics for pre-and post-test summed scores when analyzed by school location. The JMG lessons were taught at two schools, Zunil and Olintepeque. Each school had two sixth-grade classes, designated as “A” and “B” to distinguish between groups.

A significant difference (t = -7.52, df = 3, $\alpha < 0.005$) with a large correlation (d = 1.1) existed for post-test scores between schools. OlintepequeB students achieved significantly higher science knowledge post-test scores (M = 17.00, SD = 1.76) than did students at ZunilA or ZunilB (M = 14.96, SD = 2.50; M = 14.53, SD = 2.27, respectively). This significant difference may be explained by variances in the school atmosphere and teacher attitudes between the two schools. No significant differences were found when analyzed by gender, although other studies have indicated differences between boys’ and girls’ interest and ability to learn science (Baram-Tsabari & Kaadni, 2009; Klemmer et al., 2005).

Students’ Attitudes toward Science

Objective two was to determine the effect on students’ attitudes toward science, when analyzed by pre- and post-participation in selected JMG lessons. To answer this objective, participants completed the *Survey of Students’ Attitude toward Science* (see Table 3).

To determine the overall shift in participants’ attitudes toward science, individuals’ scores for the science attitude scale were summed and a paired samples *t*-test was conducted. No significant difference was found between pre-test (M = 31.83, SD = 6.73) and post-test scores (M = 32.64. SD = 5.97) for the science attitudes scale. Students agreed in both pre- and post-tests that they would like to work in science or be a scientist in the future, science classes are exciting, and they do well and learn quickly in science classes. Students disagreed in both pre- and post-tests that they would not like to study science in the future, science classes are not interesting, we do not learn interesting things in science classes, and peers think science classes are boring.

Teachers’ Perceptions of Selected JMG Lessons

Objective three was to measure teachers’ perceptions of the selected JMG lessons and their effectiveness in teaching scientific concepts and influencing students’ perceptions of science. Teacher participants completed the *Evaluation of the JMG curriculum* post-participation in selected JMG lessons (see Table 4).

Tests of significance were not conducted for this data because of the low sample size (N = 11) (Fraenkel & Wallen, 2009). Casual observations of the means for each question are useful in determining teachers’ perceptions of the selected JMG lessons. Teachers disagreed with all eight of the negatively phrased statements, agreed with seven, and strongly agreed with three of the positively phrased statements regarding the selected JMG lessons.

Table 1

Distribution of Responses to Science Knowledge Questions (N = 83)

	Pre		Post	
Questions[c]	*f* [a]	% [b]	*f* [a]	% [b]
Which one of the following do plants not need to survive? (Butterflies)	40	47.6	75	89.3
Which one of the following is not a part of a plant? (Worms)	51	60.7	40	47.6
Corn is an example of a: (Seed)	71	84.5	81	96.4
Broccoli is an example of a: (Flower)	29	34.7	53	63.1
Carrots are an example of a: (Root)	61	72.6	74	88.1
Which part of the plant is responsible for creating food? (Leaves)	14	16.7	17	20.2
Which part of the plant is responsible for providing strength and support against the wind and rain? (Stem)	37	44.0	41	48.8
Which image is not a part of soil? (Trash)	44	52.4	58	69.0
The blue particles are the biggest and represent: (Sand)	33	39.3	56	66.7
The red particles are the smallest and represent: (Clay)	26	31.0	41	48.8
This image is an example of: (Evaporation)	61	72.6	64	76.2
This image is an example of: (Transpiration)	37	44.0	32	38.1
This image is an example of: (Precipitation)	49	58.3	42	50.0
This image is an example of: (Evaporation)	58	69.0	52	61.9
How much of the earth's surface is covered in water? (3/4)	54	64.3	51	60.7
Order the images below in the correct order of the food chain. Number 1 represents the inferior part and number 6 represents the superior part of the food chain. (1= Dead leaves, 6 = Falcon)	65	77.4	62	73.8
It is healthy to eat more cookies than apples. (False)	49	58.3	77	91.7
It is healthy to eat more bread and tortillas than meat. (True)	78	92.9	49	58.3
I should eat fruits and vegetables every day. (True)	31	39.2	81	96.4
Which one of the following images represents mimicry? (Image of butterflies)	39	46.4	45	53.6
Which one of the following images represents camouflage? (Image of green insect)	42	50.0	44	52.4
Which one of the following images represents reverse camouflage? (Image of red insect)	26	31.0	37	44.0
Which of the following is not a benefit of insects? (Spread of diseases)	53	63.1	57	67.9
Which of the following is a benefit of insects? (Decomposition)	19	22.6	24	28.6
Insects use ____ to communicate? (Noses)	12	14.3	26	31.0

Note. [a]Frequencies represent number of students who correctly answered each question. [b]Represents percentage of students who correctly answered each question. [c]Answers to each question are given in parenthesis.

Table 2

Impact of School Location on Pre-and Post-test Summed Scores(N = 82)

Dependent Variable	School Location	*n*	*M*	*SD*	*F*	*p*
Summed score of pre-test	ZunilA	23	14.04	2.84	1.06	0.37
	ZunilB	19	12.74	2.73		
	OlintepequeA	22	12.86	3.36		
	OlintepequeB	17	13.59	1.62		
	Total	81	13.32	2.77		
Summed score of post-test	ZunilA	23	14.96*	2.50	4.34	<0.01
	ZunilB	19	14.53*	2.27		
	OlintepequeA	21	16.00	2.70		
	OlintepequeB	19	17.00*	1.76		
	Total	82	15.60	2.49		

Note. *The mean difference is significant at the 0.05 level.

Table 3

Students' Attitudes of Science (N =79)

	Pre		Post	
Statements:	*M*[a]	*SD*	*M*[a]	*SD*
I would **not** like study more science in the future	2.43	1.38	2.23	1.35
I would like to work with science in the future	3.53	1.27	3.94	.93
I think I could be a good scientist one day	3.74	1.24	3.85	1.05
I am excited to go to science classes	3.74	1.14	3.87	.97
Science classes are **not** interesting	2.39	1.18	2.27	1.13
We do **not** learn interesting things in science classes	2.28	1.27	2.18	1.16
I do well in science classes	3.74	1.13	3.67	1.09
My friends think science classes are **boring**	2.44	1.18	2.55	1.21
I learn things quickly in science classes	3.91	1.45	3.97	1.15

Note. [a]Five-point Likert-type scale: 1 (*Strongly Disagree*) to 5 (*Strongly Agree*); 3 (*No Opinion*).

Table 4

Teachers' Perceptions of JMG's Effectiveness and Influence on Students (N = 11)

I believe Junior Master Gardener (JMG) lessons …	*M*[a]	*SD*
Were important in enhancing my students' current studies	4.18	.41
Were **not** important in enhancing my students' science learning abilities	1.73	.47
Were **not** applicable or relevant for students in developing countries	1.80	.63
Were important in stimulating my students' desire to learn more about science	4.55	.52
Contained important information and activities for students in developing countries	4.27	.47
Are an educational tool I would like to incorporate in the future	4.55	.52
Are an educational tool I feel comfortable using	4.09	.54
Were **not** effective in teaching my students about plant needs	1.64	.51
Were effective in teaching my students about plant parts	4.45	.52
Were **not** effective in teaching my students about different soil types	1.73	.47
Were effective in teaching my students about soil composition	4.36	.51
Were effective in teaching my students about the water cycle	4.36	.51
Were **not** effective in teaching my students about soil erosion	1.64	.51
Were effective in teaching my students about the food chain	4.55	.52
Were **not** effective in teaching my students about the food web	1.45	.52
Were **not** effective in teaching my students about insect survival mechanisms	1.91	.83
Were effective in teaching my students about the benefits of insects	4.36	.51
Were effective in teaching my students about nutritional needs	1.73	.47

Note. [a]Five-point Likert-type scale: 1 (*Strongly Disagree*) to 5 (*Strongly Agree*); 3 (*No Opinion*).

Conclusions and Recommendations

This study revealed a significant difference existed between students' pre- and post-test scores for the science knowledge test after six weeks of JMG lessons. No changes in attitude toward science were observed in the student data; however, data from teachers' surveys indicated teachers perceived JMG lessons were important in stimulating students' desires to learn science and in increasing students' interests in science.

Although students in both schools had increased scientific knowledge gain, the post-hoc ANOVA revealed that the level of increase was different at each school. This is most likely attributed to differences in school atmosphere and teacher attitude. Zunil sixth-grade teachers left the classroom during the researcher's JMG instruction time, as opposed to Olintepeque teachers who stayed in the classroom to help manage, discipline, and motivate students during the JMG activities. The results of the post-hoc analysis appear to reflect the differences of teachers' attitudes on students' abilities, willingness to learn, and understand scientific concepts. These findings confirm research indicating teacher attitude, participation, and discipline impact students' abilities to learn (Allen, Witt, & Wheeless, 2006).

Practical implications for future JMG teachers would be to encourage all teachers to participate in JMG lessons to promote student learning and interest in JMG activities. Such encouragement will equalize student learning environments and could minimize impact that external effects have on student learning. Future studies should consider evaluating the impact that teachers' participation or teaching style has on student learning.

Because JMG increases students' scientific knowledge through fun and creative activities, it should be considered a strategic tool by international development programs focused on improving education and/or science education in developing countries. Research shows STEM education is closely related to a country's development; strengthening students' skills needed to understand and solve scientific problems will be useful in creating a strong foundation for a country's future (Osborne, Simon, & Collins, 2003).

No significant difference was found between pre- and post-summed scores for science attitudes. Students' attitudes about science were positive before and after participation in selected JMG activities. This finding is in line with research that suggests students at younger ages, such as those in this study, typically have more positive attitudes toward science than their older peers who have entered secondary education (Murphy & Beggs, 2003; Osborne, Simon, & Collins, 2003). The main reason for this being that younger students tend to be engaged in more hands-on and inquiry-based scientific activities, whereas older students tend to be taught in a more traditional sense with lectures, memorization, and exams (Gibson and Chase, 2002). Research shows it is difficult for students to maintain their interest in science if they are unable to see the relevance of what they are learning to their everyday lives (Osborne, Simon, & Collins, 2003). Junior Master Gardeners and similar agricultural education programs, which focus mainly on hands-on experiential learning, therefore have the potential to be used as tools in the school setting to help keep students' interested in science as they age.

For future studies, experts in educational psychology should review the instrument for internal validity to ensure children are comfortable with and understand the phrasing, structure, and complexity of questions. Also, native Guatemalan teachers should review the Spanish version after initial translation to ensure linguistic equivalence and increase reliability.

Teachers had a positive perception toward the selected JMG lessons. They believed JMG lessons were important in enhancing students' science learning abilities, stimulating students' desire to learn science, enhancing science curriculum, and were effective in teaching a variety of scientific concepts. Teachers also indicated they would feel comfortable incorporating and would incorporate JMG lessons into future science curriculum because the JMG lessons were relevant and important for students studying science in developing countries.

Even though students' data indicated no change in science attitude, teachers perceived that JMG lessons contributed significantly to a child's understanding and interest in science. Future studies should test the impacts of the JMG program on a larger group of teachers for more time to see if results are consistent. Teachers should evaluate the usefulness and practicality of various JMG lessons. While conducting this study, it was noted that some lessons in the *Junior Master Gardener teacher/leader* *guide: Level one* were deemed as culturally inappropriate or difficult to execute because of lacking resources and/or time. For example, JMG lessons about landscaping, certain crops and animals unique to the U.S., and ideas, concepts, and people significant to American history do not make sense to a rural Guatemalan child.

To make JMG curriculum more effective and applicable for teachers in rural Guatemala, practitioners should survey local teachers and conduct an evaluation to determine which lessons are acceptable, which can be easily modified, and which should be completely discarded in this cultural context. Future study will make it easier for teachers interested in JMG to more easily incorporate it into their science curricula.

Overall, there is much potential for future research and curriculum development with the JMG program. If previously discussed steps are taken to improve evaluation and applicability of the JMG program, JMG has valuable potential for international development projects seeking to improve science education and empower youth. JMG programs equip youth with improved scientific knowledge that may help them to transform their lives and the lives of those around them.

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