Coverage and Outcomes of the Space Agriculture in the Classroom Curriculum

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Abstract

The Space Agriculture in the Classroom curriculum entitled "Growing Space" was piloted in four states for the 2003-2004 school year in 6th grade classrooms. A follow-up study was conducted to assess whether the project's goals are being met. These include creating an interest in space agriculture careers among minority and urban students and exposing students of all races and backgrounds to the topics involving space and agriculture. A questionnaire was sent to all 395 teachers who received curriculum packets, with 184 teachers (47%) responding. Of the responding teachers, 154 (84%) used the curriculum. Based on teacher reports, 38% of the students in participating classrooms were of a minority group. Teachers also responded positively to questions regarding the interest of minority students in space and agriculture topics. The Space Agriculture curriculum also reached many students in cities and suburbs. Overall, this study provides evidence that the Space Agriculture in the Classroom curriculum is, in part, meeting its goals.

Introduction

The Space Agriculture in the Classroom (SAITC) program is a joint initiative of the Agriculture in the Classroom (AITC) program of the Cooperative State Research Extension and Education Service (CSREES), United States Department of Agriculture (USDA), and the Office of Biological and Physical Research, National Aeronautics and Space Administration (NASA). The Space Agriculture in the Classroom program was created in 2001 to address concerns from USDA and NASA about sustaining an adequate supply of agricultural scientists, engineers, technicians, and producers in the next three decades.

Since the early 1980s, NASA has been providing educational materials and programs through their Farming in Space Program to a relatively small, nationwide group of classroom educators. Through this partnership, USDA has recognized that NASA's vision of controlled environment farming on long duration space missions could capture the interest of technologically-oriented students and teachers. Moreover, this approach was seen by USDA as an opportunity to increase agricultural literacy for a larger number of America's youth - a problem that the National Research Council (1988) has decried for some time. Because agriculture plays a critical role in space activities through plants that provide food, regenerate oxygen, remove carbon dioxide and purify water for long duration space missions, both organizations saw the partnership as highly symbiotic.

The primary academic partner of the Space Agriculture in the Classroom program is the Department of Agricultural Education and Communication at the University of Florida. The University of Florida's role in the Space Agriculture program is to provide educators with instructional materials created by the Space Agriculture in the Classroom project team in the Department of Agricultural Education and Communication and NASA's Office of Biological and Physical Research. The content of the space agriculture curriculum included current NASA research in space agriculture, and connected this research to benefits for local and national agriculture production and related areas such as food safety and nutrition.

In essence, the project was designed to enhance student awareness of agricultural practices and the terrestrial application of space-based technologies. Specifically, the near-term goals of the Space Agriculture in the Classroom program were to:

1. Increase awareness of and interest in agricultural and space sciences among middle school students.
2. Increase understanding of agricultural activities in space and on Earth.
3. Stimulate interest in careers in agriculture and engineering.
4. Secure the participation of teachers and students in urban schools.
5. Secure the participation of large numbers of minority students.

With an interest in serving a wide range of students at a stage of early opinion formation, sixth grade science students and teachers were identified as the target audience for the initial year of the project. The Space Agriculture in the Classroom curriculum was developed during the 2003-2004 school year. This curriculum included a high-gloss magazine entitled "Growing Space" with pictures and graphics written on a sixth grade reading level and formatted to be interesting to those students. Lesson plans and science experiments written for use alongside the magazine also were provided, including a laboratory activity to compare the growth of "space" and "earth" wheat. PowerPoint presentations and supplemental resources were provided via the Space Agriculture in the Classroom Web site (www.spaceag.org) to be accessible to teachers at all times. The Growing Space magazine and wheat seeds were assembled into classroom sets for participating teachers. Because the program was designed to reach large numbers of students, the materials were prepared for use "as is" and no teacher workshops were provided.

When the curriculum materials were completed, a letter and sample copy of "Growing Space" magazine was sent to over 3,700 middle school science teachers in Alabama, Florida, New Mexico, and Utah to alert them about the program and provide information on procedures for participating. The list for Alabama contained 322 teachers, Florida 2,462, New Mexico 187, and Utah 771. All of the Alabama and New Mexico teachers were National Science Teachers Association (NSTA) members. For Utah, 359 teachers were NSTA members and the remainder Applied Technology teachers. The Florida teachers were identified from Florida Department of Education's list of middle school science or self-contained 6th grade teachers who presumably taught science.

A total of 395 teachers requested a classroom set of materials during Fall, 2003 and Spring, 2004. Statewide coverage of the program was sought, but emphasis was placed on recruiting teachers in urban schools, which would also secure the participation of large minority student populations.

In order to determine if the project's goals were being met, an evaluation of the Growing Space curriculum was designed and implemented by members of the Space Agriculture in the Classroom project team at the University of Florida. This paper reports the results of the study and presents recommendations for strengthening the program.

Conceptual Framework

This study drew on Rossi, Freeman, and Lipsey's (1999) work regarding systematic evaluation. Their work involves a comprehensive approach that employs both formative and summative methods during the lifecycle of the project. The formative elements of the evaluation include assessing the coverage and delivery of the program. Program coverage is high when the target population is engaged in the program, at least to the extent allowed by the available resources. In addition, there should be no significant bias in coverage which can result from some groups participating less than others. For example, the Florida Agriculture in the Classroom program has been successful in recruiting teachers and students from rural schools but less so in suburban and urban schools (Malecki, 2003; Malecki, Israel, & Toro, 2004). A key concern for stakeholders was the ability of the program to reach suburban and urban students.

Similarly, delivery of the program is affected by the quality of the educational materials, the ease of use and adaptability of the materials, accessibility of program resources for teachers and students (in this case, through the World Wide Web), and compatibility with existing curriculum and state standards. In the case of the "Growing Space" curriculum, the educational materials were developed to meet national science education standards. Findings from an assessment of coverage and delivery of the program can be used to fine-tune a continuing program.

The project team also worked closely with stakeholders from NASA and USDA to plan the program and to incorporate key questions and concerns into the evaluation design so that a focus on utilization (Patton, 1997) was maintained. This participatory approach employed logic models as a tool to focus the program design and to identify outcome measures for the summative component of the evaluation. Logic models provide a graphical display of the key components and processes for a program (Israel, 2001; Rossi et al. 1999). Logic models vary in complexity, with comprehensive models incorporating features of both program organization and service delivery (a process model) and program outcomes (an impact model). Figure 1 shows the short-term and distal outcomes that were identified by the Space Agriculture in the Classroom project team and stakeholders. Since participation is voluntary (see Hatry, 1999), the immediate outcome for the program was to recruit teachers to request a classroom set of materials and to use these materials. Other short-term outcomes focused on student-level measures, as shown in Figure 1.

Based on the logic model, the summative evaluation of the program should focus on measuring net changes in student-level outcomes. Net changes are those attributed to the program after confounding factors and design effects have been taken into account (Rossi et al., 1999). Consequently, some evaluation designs provide a more rigorous assessment of program impact than do others. Because the Space Agriculture in the Classroom program is a partial coverage program (that is, a minority of the potential audience could be accommodated by the program), a strong evaluation design would incorporate a control group. Successively weaker designs would omit a control group and rely on a post-only data collection design. The latter design is adequate, however, when alternative explanations for observed changes can be reasonably ruled out (Rossi et al., 1999:363). In the case of the "Growing Space" curriculum, the choice of measures and collection of follow-up data shortly after implementation are likely to have limited opportunities for factors outside the program to influence the results. Furthermore, key stakeholders found the post-only design to be an acceptable approach.

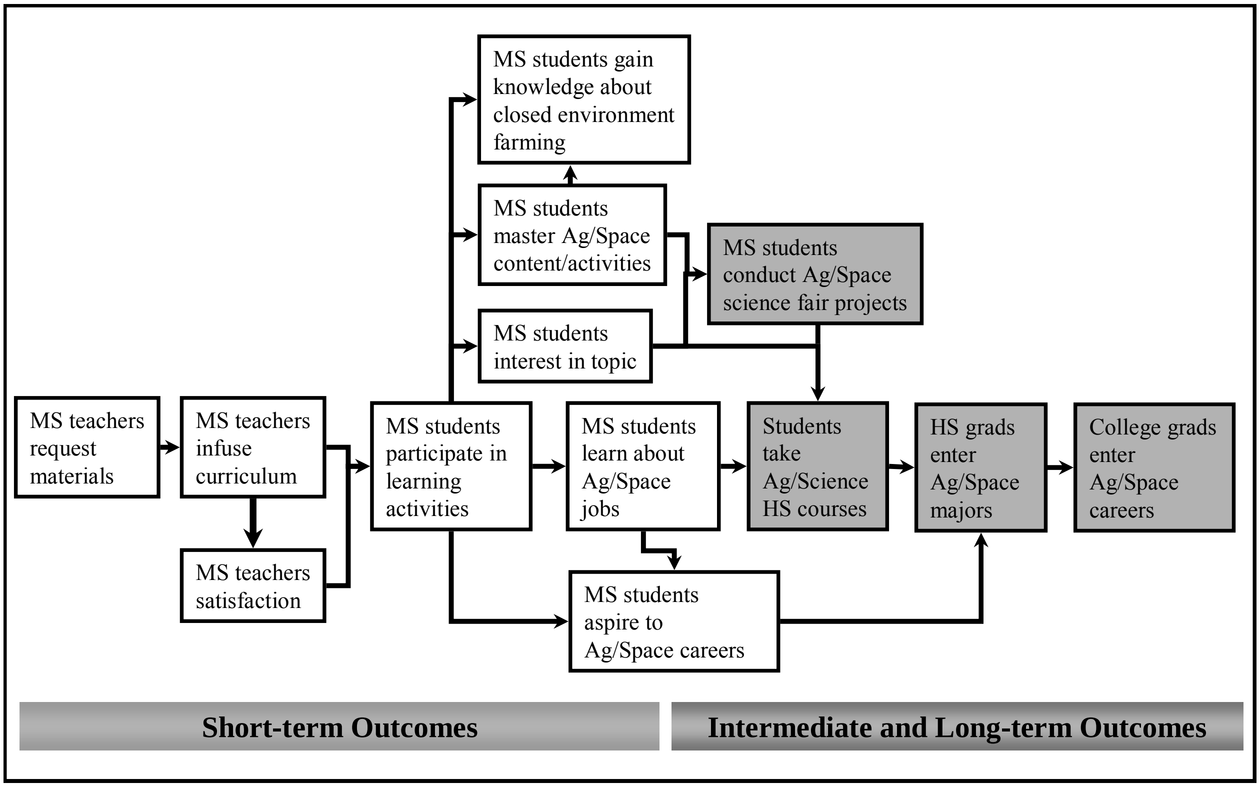

Figure 1. *Impact Model for Space Agriculture in the Classroom Project.*

Purpose and Objectives

The purpose for evaluation of the Space Agriculture in the Classroom during its initial year of implementation was to ensure that the goals of the Space Agriculture in the Classroom program were being met. The *evaluation objectives* were to:

1. Assess whether program staff were successful in recruiting teachers and students in the target groups, specifically minority and urban students.
2. Assess the extent to which students were interested in and gained knowledge from the curriculum.
3. Assess whether the program stimulated students' interest in relevant careers.
4. Assess the functionality and utility of the curriculum materials for teachers.

The fourth objective was included to allow the project team to fine-tune materials and protocols before expanding the program into a larger number of states during the second and third years of the project.

Procedures

During the 2003-2004 school year, the Space Agriculture in the Classroom curriculum was piloted to 6th grade classrooms in four states: Florida, Utah, New Mexico, and Alabama. A small number of teachers from other states who requested the information were included as well. In an effort to evaluate the effectiveness of the curriculum in alignment with the goals determined by the Space Agriculture in the Classroom project team, a survey instrument was sent to all 395 teachers who received the curriculum.

The instrument contained questions that asked respondents to report on classroom and teacher demographic data, students' reactions to the curriculum, and their reactions as educators to the curriculum. Questions about demographics asked teachers to identify the grade level with which the curriculum was used, how many students were in each class and the racial composition of students (African American, Asian American, Hispanic, Native American, and Other), and how long the teacher had been in the profession. Note that teacher reports for the racial composition may be based on either teacher perceptions or knowledge of official school records.

Next, seven items asked teachers for their observations about students' responses to the curriculum. Although collecting data directly from students is desirable for assessing learning and interest, this was outweighed by logistical problems for obtaining human subjects clearance to survey individual students and its associated costs. Some teachers might also overstate the extent of students' interest and learning because of his or her personal investment in using the curriculum. The items about students' responses to the curriculum were followed by 10 items that asked for teachers' perceptions about accessing and implementing the curriculum. The items on students' responses to the curriculum and teachers' implementation used a Likert-type scale with five categories ranging from "Not True" to "Completely True" as well as a sixth "No Opinion" option.

The last section of the survey asked three open-ended questions. The first asked for reasons why the respondent would recommend the Space Agriculture in the Classroom curriculum to other teachers. This was followed by questions asking respondents to list topics they would like to see added to the curriculum and to identify any problems they encountered in accessing or using the curriculum. The complete instrument was reviewed by project team members for face validity. Given the type of data being collected, no further testing was conducted.

The data collection process was initiated late in the school year to allow teachers to complete implementation of the curriculum. Following Dillman's (2000) work, a pre-letter was sent to teachers to alert them to the survey. This was followed five days later by a cover letter and the questionnaire. After, a reminder postcard was mailed to non-respondents and, if necessary, a second round of the survey was also mailed to non-respondents. These steps brought the adjusted response rate to 47% (n = 184). At the time of the survey, three of the 395 teachers could not be contacted because they had retired or moved.

The data from each responding teacher were matched with school information contained in the Common Core of Data from the National Center for Educational Statistics' (NCES) Web site. The NCES data included enrollment numbers, ratio of teachers to students, division of the student population by race, the type of school (charter, magnet, or regular), the number of students on reduced lunch, as well as the location of the school. The NCES uses eight categories for this data: Large Central City; Mid-size Central City; Urban Fringe of Large City; Urban Fringe of Mid-size City; Large Town; Small Town; Rural, outside Metropolitan Statistical Area (MSA) and Rural, inside MSA. There were eight schools or organizations that were not listed on the NCES database. This was because they were too new or because the organization was not a public school. Knowing this information about the specific school allowed the researchers to assess the type of schools and students that the Space Agriculture program was reaching, because one of the initial goals of this program was to reach minority and urban students. The location data also was used to compare respondents and non-respondents. A Chi-square test showed that there was no significant bias in the data based on location ($\chi^2 = 2.9$, significance level = .894).

The data analysis in this study focused on descriptive statistics. All analyses were conducted using SPSS 12.0 for Windows.

Findings

Participation and Use of the Curriculum

Out of the 3,742 teachers who were sent information on the "Growing Space" curriculum, 395 requested and were sent classroom sets, with 356 of these from the four pilot states -- a participation rate of nearly one in ten. Twenty-three teachers participated from Alabama, 248 from Florida, 9 from New Mexico, and 77 from Utah. Another 39 teachers from other states requested classroom sets. Although the adoption rate for a new curriculum, which also was not mandated and required the teacher to infuse it into an existing curriculum during the school year, might be considered impressive, it was somewhat below the program's capacity. According to project records, 21,500 of the available 30,000 copies of "Growing Space" were distributed.

Of the 184 teachers who responded to the survey, 154 (84%) used the curriculum in their classes. The remaining 16% who returned questionnaires often included a reason why they had not been able to use the curriculum during the school year. It also is likely that a large percentage of survey non-respondents did not use the curriculum.

Although the 2003-2004 Space Agriculture curriculum was intended for sixth graders, the survey respondents reported using the curriculum with students ranging from Kindergarten to 12th grade. Of the teachers who used the curriculum, 66% (n = 101) used the materials with 6th grade classes, as intended. Also, some teachers used the curriculum with other students of middle school age. There were two teachers (1%) who used the curriculum with 5th graders, and 44 teachers (29%) who used it with 7th or 8th graders.

Overall, many of the teachers who used the curriculum had a large class size, with the median at 30 students. Six percent (n = 9) of the classes where "Growing Space" was used had less than 15 students. Seven percent (n = 10) of the classes reported having 15-20 students and 19% (n = 29) of classes had 21-25 students. Another 20% (n = 31) of respondents reported having 26-30 students. Sixteen percent (n = 24) of classes were between 31 and 40 students. Classes larger than 40 students made up 33% (n = 51) of the respondents. There is evidence that some teachers used the curriculum with more than one class, which may have resulted in the large percentage of teachers who had more than 40 students.

The 154 teachers who used the Space Agriculture in the Classroom curriculum taught a total of 9,378 students. The curriculum reached 1,591 African American students (17%), 1,414 Hispanic students (15%), 268 Asian American students (3%), 258 Native American students (3%), and 5,487 students noted as "Other" (59%). Note that the "Other" category includes Caucasian students as well as other minorities (Figure 2). Also, two respondents included a total number of students but did not identify their students by specific race categories. A few teachers reported the total number of students but when they reported students by race it did not equal the total. Thus, the race is unknown for 333 students (3%).

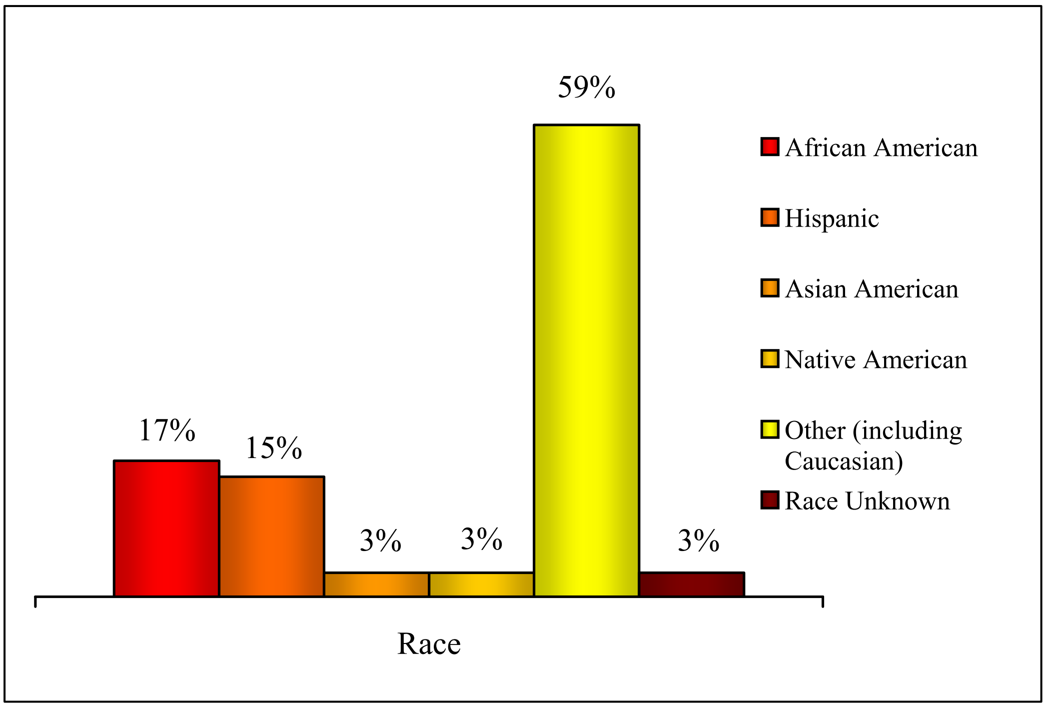

Figure 2. *Percentages of student participants by race.*

Of the 9,378 students who were taught using the Space Agriculture curriculum, it can be seen in Figure 3 that 74% (n = 6,932) of students were enrolled in schools in the top four most urban categories (Large Central City, Mid-size Central City, Urban Fringe of Large City, and Urban Fringe of Mid-size City). The total unduplicated number of schools who used the curriculum is 154. Figure 3 also shows that 75% (n = 116) of schools that used the curriculum were from these same top four urban categories.

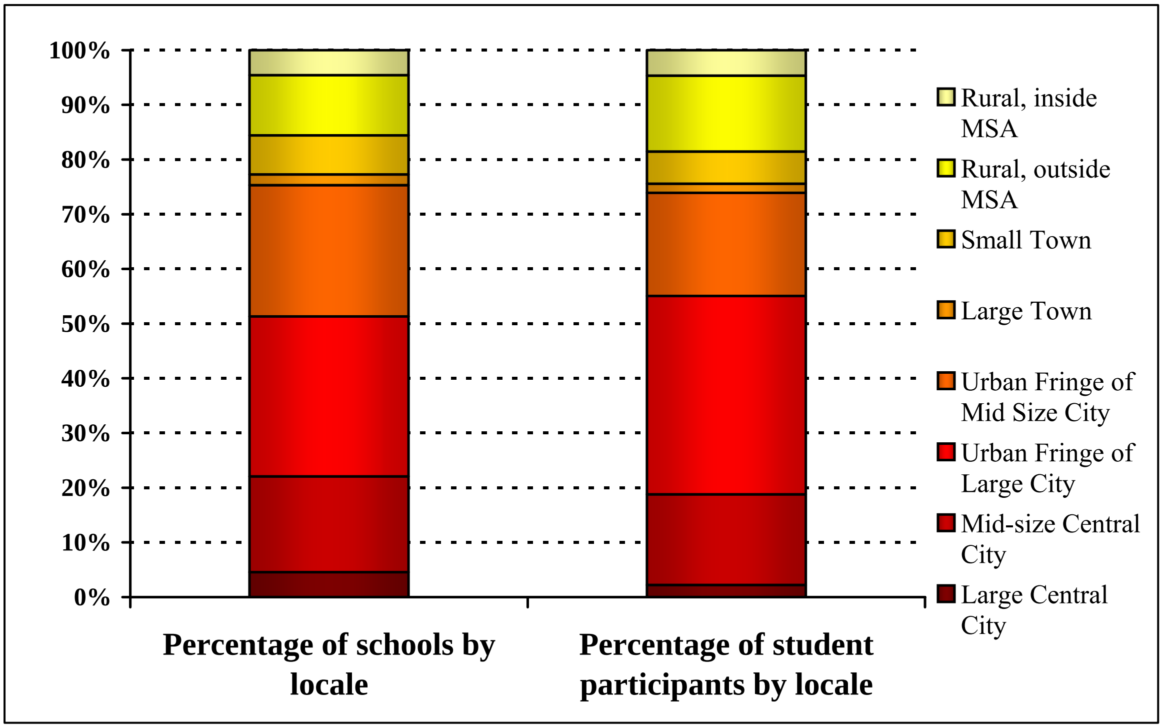

Figure 3. *Percentage of schools and student Space Agriculture in the Classroom participants by locale.*

Of teachers using the curriculum, most were experienced professionals. Teachers reported working an average of 13.9 years in the education profession. Relatively few early-career teachers used the curriculum, with 17% (n = 26) having taught less than 3 years.

Student Outcomes

The data in Figure 4 show responses to the items regarding students' reactions to the curriculum and teachers' responses to the usability and effectiveness of the curriculum. These data show that the general response among students to the curriculum was very positive. For example, one teacher wrote, "I found the program to be very interesting for my students and me. The materials were up to date and relevant. The students found the water recycling fascinating." Another reported that "It allows the student to draw their own conclusions from the information given and it allows them to experience another aspect of science they may not have much knowledge about." A third wrote, "Good hands on learning experience - also good way to generate excitement about space/agriculture combination." A large majority of teachers reported that the material stimulated interest in science. Moreover, the materials were interesting and understandable across diverse student populations. Finally, the Growing Space curriculum was partially successful in stimulating interest in careers in space and, less so, in agriculture.

Curriculum Functionality and Utility

The responses to curriculum implementation are shown in Figure 5. Teachers were asked questions based on the usability and effectiveness of the curriculum and their answers were generally positive. A large majority of teachers reported that the "Growing Space" magazine was easy for their students to understand. "Growing Space was excellent!" wrote one teacher. Some teachers agreed with the statement that the magazine was written on an appropriate reading level, but the responses to this question could be skewed by the fact that some teachers did not use the curriculum with 6th grade classes as it was intended. The general consensus was that the classroom supplies were easy to use, but it seems that some teachers may have had trouble finding the time and resources to fit Space Agriculture into their classes. "It is excellent - just didn't fit my curriculum," a teacher reported. In general, teachers responded positively that the curriculum corresponded with their state standards for education, however, only a slight majority indicated that it helped to prepare for the standardized tests in that subject area.

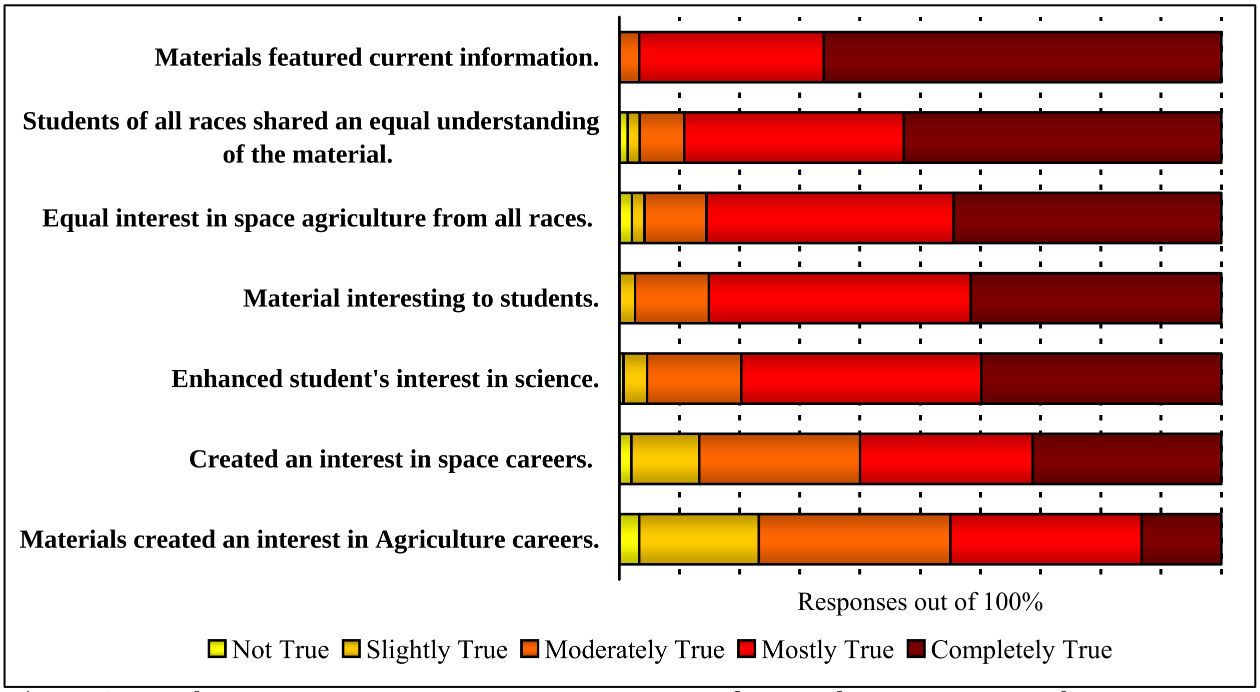

Figure 4. *Teachers' responses to survey questions regarding student reactions to the Space Agriculture in the Classroom curriculum.*

Respondents' reaction to supplemental teaching materials is displayed in Figure 6. A majority of respondents agreed with the statement that the pre-written lesson plans were easy to adapt for use in their classroom. For example, one teacher reported, "It is really easily organized, excellent work sheets and activities." Teachers reacted very positively to the Space Agriculture in the Classroom Web site, reporting that it was easy to navigate and the site's links were useful. Respondents generally reacted positively to the PowerPoint presentations that were provided on the Internet, agreeing that they were useful and could be easily modified. But more teachers rated PowerPoint materials as "moderately useful" or lower than the other supplemental materials and, based on the comments, some of these teachers had little experience with PowerPoint and, as a consequence, had trouble modifying the presentations.

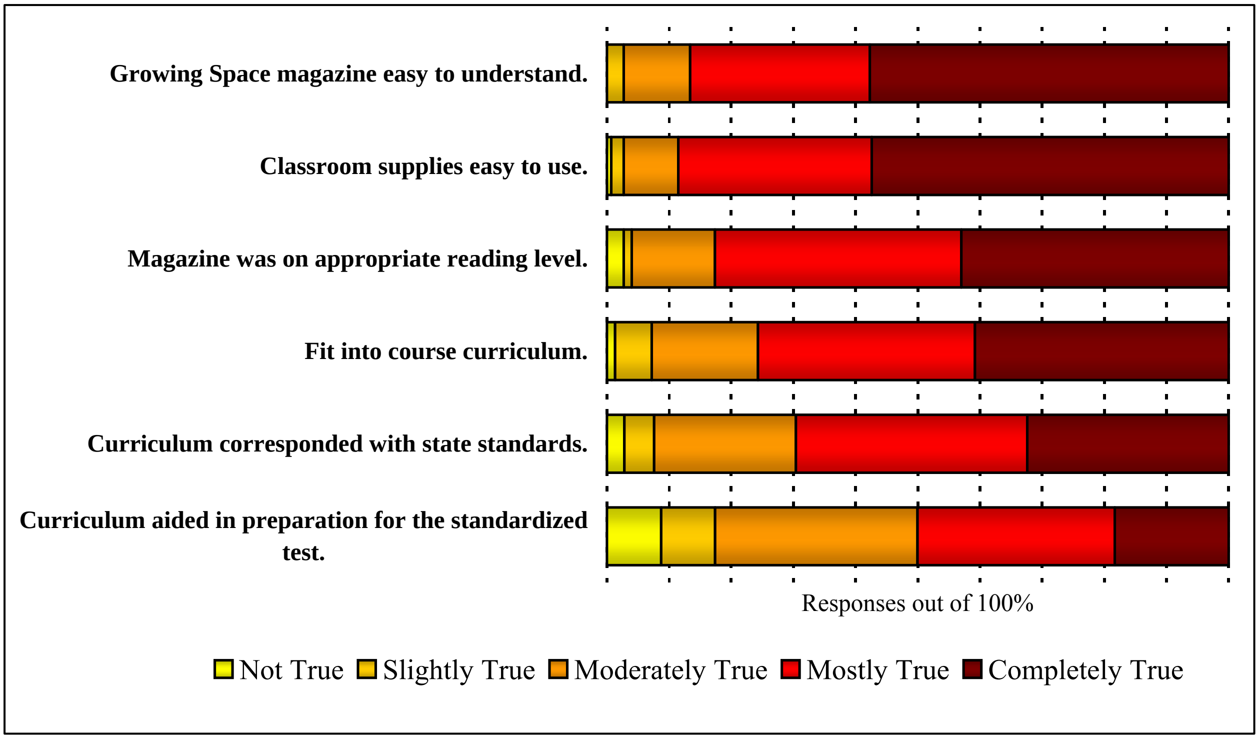

Figure 5. Teachers' responses to curriculum implementation questions regarding Space Agriculture in the Classroom materials.

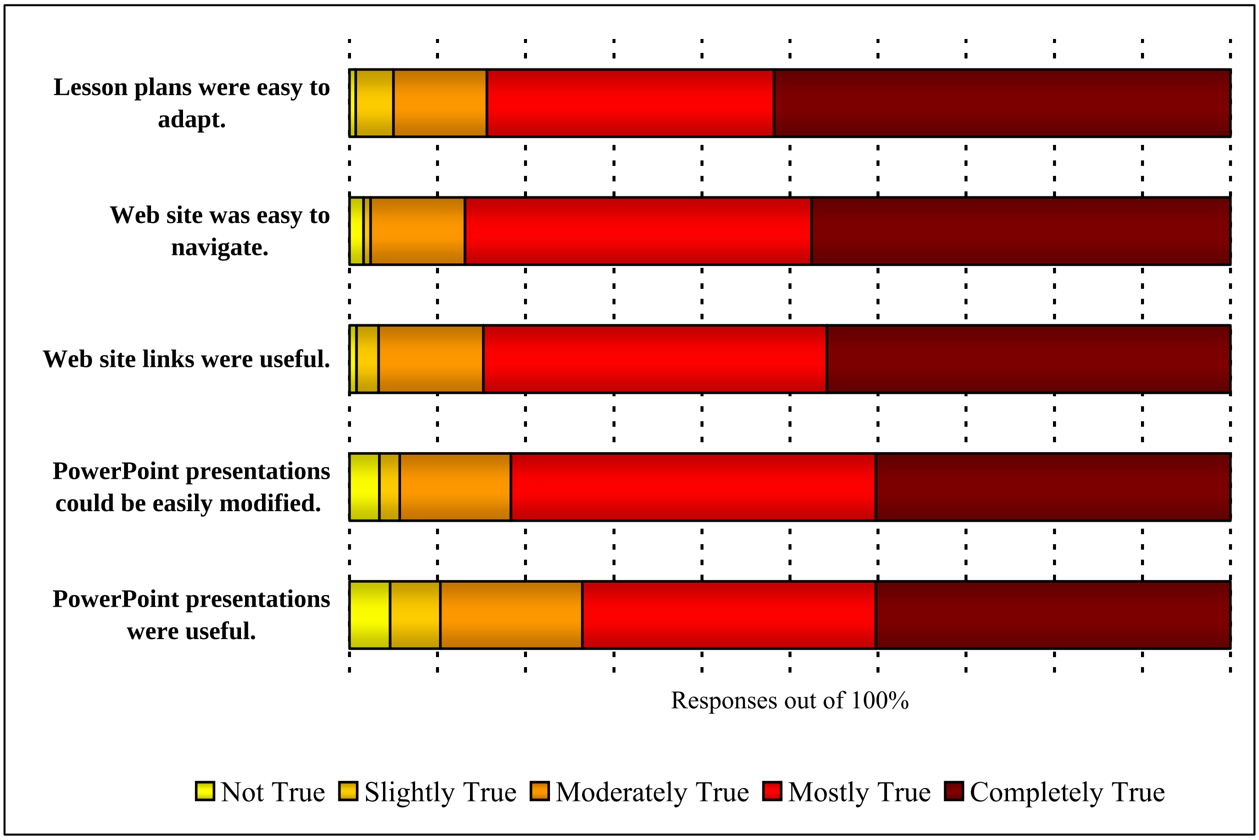

Figure 6. Teachers' responses to questions regarding supplemental teaching resources.

Conclusions

The evidence from the follow-up survey on the Space Agriculture in the Classroom curriculum entitled "Growing Space" supports the view that the project's goals were met in part. Though the program fell short of reaching its capacity for student participation, it was successful in recruiting teachers who work with urban and minority students. Teachers reported that 38% of the students in participating classrooms were minorities and teachers responded positively to questions regarding the interest of minority students in space and agriculture topics. The Space Agriculture curriculum also reached many students in cities and suburbs.

The program also met goals for exposing students of different races and backgrounds to the topics involving space and agriculture for their benefit and, to a lesser extent, in creating an interest in space agriculture careers among minority and urban students. Though the evidence regarding student outcomes is far from definitive, the observations about the program's benefits by educational professionals cannot be discounted. The finding that the materials were interesting and understandable across diverse student populations is important because it contributed to the goal of recruiting and engaging minority students in the Space Agriculture in the Classroom program. On the other hand, progress toward the goal of stimulating interest in careers in agriculture was limited, which might have been due to the short duration of the curriculum.

The delivery of the program was generally successful from the perspective of teachers who responded to the survey. A large majority of teachers reported the "Growing Space" curriculum to be usable and effective. This is important because the magazine was the key resource for students to read. In addition, a number of teachers included positive comments about the curriculum and provided suggestions for additional topics to include in new materials. Most teachers indicated the resource materials were easy to use and adaptable but a few experienced challenges with accessing and using Web-based materials. Aside from streamlining materials to reduce download times, few issues were identified that related to delivery. Finally, there was evidence that some teachers had trouble fitting Space Agriculture into their existing curriculum which suggests that some practice with the material is needed before it is integrated into the classroom.

Recommendations

Based on the findings, the Space Agriculture materials can be improved by providing additional guidance for infusing the materials into existing classroom curricula and increasing access to the supplementary resources. In the case of the former, project team members should secure resources to conduct workshops and presentations at professional development conferences for teachers. The workshops will need to focus on strategies for infusing the materials and linking the information to careers in agricultural and space-related sciences. In order to increase access, lesson plans and PowerPoint presentations should be copied to CD-ROM discs and included in the classroom packets that are sent to teachers. In addition, future distribution should provide a set for each classroom rather than a single set per teacher to compensate for wear and tear from heavy use.

It is also clear that additional efforts should be focused on recruitment. Given that the program has the capacity to involve more teachers and students, marketing efforts should be intensified to reach the target audience - 6^{th} grade teachers. In addition to direct mailings to teachers, program personnel might rely on surrogates to advertise and promote the program. This could be done in two ways: 1) Expand the visibility of "Growing Space" in NASA's extensive outreach to public schools, and 2) Contact science curriculum specialists in state departments of education. Support from state departments could help legitimize the curriculum in the eyes of teachers and school districts.

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