Middle School Students’ Science Career Interests Improve with School Garden and STEAM Projects Elective Course

Abstract
The need for high-wage STEM workers is increasing faster than the number of students who are majoring in STEM fields. Traditionally middle school students’ positive attitudes toward science and mathematics careers decline. A school garden (added in 2021 through a university and school partnership) and STEAM learning were implemented in a middle school in the intermountain west of the U.S. to increase underutilized groups’ (e.g., females and students of color) interest in STEM careers. A pre-STEAM-CIS survey was given in the fall of 2021, and a post-survey in the fall of 2022. Means and t-test statistics for the differences in interest in the individual STEAM subject careers are reported. Interest in a science career increased statistically significantly for all groups. Additionally, interest in a mathematics career remained high for all groups.

Introduction
At national and international levels there is a concern about preparing students for Science, Technology, Engineering, and Mathematics (STEM) careers (e.g., Kelley & Knowles, 2018; Stoet & Geary, 2018). Varas (2016) found that the United States will likely be short 1.1 million STEM workers in high-wage positions by 2024. The number of STEM careers available is increasing faster than the number of students who are majoring in STEM fields (Dorssen et al., 2006; Torlakson, 2014). The problem is STEM career interests for students at middle school age have been found to decrease during these years (Duraković, 2022; Morrell & Ledermann, 1998). Particularly, positive attitudes towards science and science careers identified in youth at age 10 sharply declined by age 14 (Morrell & Lederman, 1998; Tai et al. 2006). Additionally, mathematics interest has been shown to significantly decrease during the middle school age years (Frenzel et al., 2012). This disconnect between careers and students’ interests has led to a search for programs that could increase interest in STEM through engagement. One such approach is school gardens and garden-based learning (Williams et al., 2018). Another approach is enrollment in art courses to increase achievement in mathematics and science (Rabalais, 2014). Integrating the arts in STEAM projects has been shown to improve achievement for disadvantaged groups, including female students and students of color in STEM subjects (Sousa & Pilecki, 2013). Referring to Square Foot Gardening which Bartholomew (2006) taught for 30 years, “Kids love to garden...From the beginning, it was obvious that Square Foot Gardening was perfect for teaching arithmetic and all kinds of math and that, in fact, anything in the scientific field is easily taught using gardening as the vehicle. But then I began to see that a teacher could readily relate all subjects to gardening” (p. 68). Female students show a high level of interest, understanding, and preference for general classroom horticultural programs (Kim et al., 2002; Song, 2008). Therefore, to investigate ways to increase interest in STEM careers, especially among females and students of color, a Science, Technology, Engineering, Art, and Mathematics (STEAM) garden-based program was implemented in a middle school in the intermountain west of the U.S.
Methods

A STEAM garden-based curriculum was developed and implemented in an elective STEAM Projects course in a middle school through a university partnership grant. Examples of the projects implemented during one school year included planning a garden space with scale drawings, accounting for the amount of sun/shade, creating and staying within a garden budget (authors, 2022), nature journaling and data documentation, and learning about the indigenous ways of companion planting through storytelling (authors, 2022). Additionally, we implemented a garden club to care for the garden year-round. The purpose of this study was to examine how a STEAM garden-based program affected students’ STEAM career interests. Our guiding research question was: How does a STEAM garden-based program affect students’ individual STEAM career interests?

Participants

IRB approval was obtained to collect data at the school and protocols were followed. Consent and assent were obtained from parents and students, and participating students took the STEAM-CIS in the fall of 2021 and 2022 (n=236). Their ages ranged from 12 to 14 years old. This school is in a mostly rural and suburban neighborhood, with the following racial percentage breakdowns: 91.5% White, 5.9% Hispanic, 1.8% multiple races, .4% Black, 2% Asian, and .2% Pacific Islander, the population of SPED/IDEA students is 9.1%, 504 5.5%, ELL .4%, and homeless .3%. Females 50.5% and males 49.4%. All school lunches were free for the 2021-2022 school year through USDA. There was a 23:1 student-to-teacher ratio at the school. The school garden, which includes six raised-garden beds and a greenhouse for indoor gardening, was available to all teachers and classes at the school.

Theoretical Framework and Instrument

In this study, social cognitive career theory (SCCT) is used as the lens to determine how interest impacts students’ intent to pursue STEM careers. This theoretical model was developed by Lent and colleagues (1994) and allows for analysis of students’ self-efficacy, outcome expectations, goals selection, interests, personal experiences, and contextual supports to predict students' STEM career interests. Additionally, choice is a major part of the theory as well as the previously mentioned tenets. This theory was the foundation for the STEM Career Interest Survey (STEM-CIS), developed by Kier and colleagues (2014), which was adapted for this study to include the arts (STEAM-CIS). The original STEM-CIS developed by Kier and colleagues (2014) was adapted to capture the interest students have in STEM subjects and connected careers. There were five discipline-specific subscales which are science, technology, engineering, art, and mathematics. The science section is given here as an example for Table 1. The same type of statements are in the rest of the STEAM-CIS for the remaining sections with the other discipline subjects replacing science.

Table 1. Science Section of STEAM-CIS Given to Students Pre and Post of the School Garden

<table>
<thead>
<tr>
<th>Science</th>
<th>SD (1)</th>
<th>D (2)</th>
<th>N (3)</th>
<th>A (4)</th>
<th>SA (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 I am able to get a good grade in my science class.</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
S2 I am able to complete my science homework.

S3 I plan to use science in my future career.

S4 I will work hard in my science classes.

S5 If I do well in science classes, it will help me in my future career.

S6 My parents would like it if I choose a science career.

S7 I am interested in careers that use science.

S8 I like my science class.

S9 I have a role model in a science career.

S10 I would feel comfortable talking to people who work in science careers.

S11 I know of someone in my family who uses science in their career.

Each statement is presented in a Likert format from 1 to 5 where 1 is Strongly Disagree 5 is Strongly agree, so a higher mean in Table 2 corresponds to a greater interest in a STEAM career. The survey has statements about how well students feel they can complete the work in this type of class, how much they enjoy the type of class, that they want to use this type of work in their future career, and if they have a role model in this type of career. Our adapted version included the arts (visual art, music, drama, etc.) in similar survey questions to the STEM subjects. For example, one of the art survey statements reads: Arts (visual art, music, drama, etc.) - I am interested in careers that require me to use knowledge of the arts. The STEM-CIS survey developed by Kier and colleagues (2014) was adapted to capture the interest students have in STEAM subjects and connected careers. All students in the school were invited to take the STEAM career interest survey in their required science course. The STEAM career interest survey was administered pre and post or in the fall of 2021 (pre-) and again in the fall of 2022 (post-).

**Analysis and Results**

This was a quasi-experimental quantitative study. Means were calculated for the pre and post-STEAM career interest survey Likert scale paired student responses. Results were analyzed by gender and by students of color, however these results were very similar to the whole group. Therefore, the whole group results are reported. The results are shown in Table 2 and Table 3.

**Table 2. Pre and Post Means for STEAM Career Interest Survey**

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Pre- (Std. Dev.)</th>
<th>Post- (Std. Dev.)</th>
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<tbody>
<tr>
<td>Science</td>
<td>227</td>
<td>3.423 (0.576)</td>
<td>3.675 (0.523)</td>
</tr>
<tr>
<td>Mathematics</td>
<td>224</td>
<td>3.857 (0.651)</td>
<td>3.872 (0.444)</td>
</tr>
<tr>
<td>Arts</td>
<td>224</td>
<td>3.511 (0.823)</td>
<td>3.520 (0.691)</td>
</tr>
</tbody>
</table>
Table 2 results indicated most students had a relatively neutral interest in the STEAM subjects and subject careers ($M>3.4$) for the pre-survey. Although the pre-survey results for science were the lowest ($M=3.423$). Post results showed an increase in interest for science, arts, mathematics, and STEM careers overall. Descriptive statistics showed that mathematics and its related careers held the most interest (pre=3.857 and post=3.872) for the students in the study. The subject and career with the overall least interest was art (pre=3.511 and post=3.520). Science career interest increased the highest from pre- (3.423) to post- (3.675). Next, we were interested to see if any of these differences were statistically significant. Therefore, we performed paired $t$-tests. The science mean difference from pre- to post-survey was statistically significant (p<0.001; see Table 3).

Table 3. Paired Differences of the Means Showing the Confidence Intervals and Statistical Significance

<table>
<thead>
<tr>
<th></th>
<th>Mean Diff.</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
<th>95% Confidence Interval</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>0.251</td>
<td>0.454</td>
<td>0.030</td>
<td>0.192 - 0.311</td>
<td>8.344</td>
<td>226</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0.015</td>
<td>0.604</td>
<td>0.040</td>
<td>-0.065 - 0.094</td>
<td>0.369</td>
<td>223</td>
<td>0.713</td>
</tr>
<tr>
<td>Arts</td>
<td>0.009</td>
<td>1.007</td>
<td>0.067</td>
<td>-0.124 - 0.141</td>
<td>0.127</td>
<td>223</td>
<td>0.899</td>
</tr>
<tr>
<td>Technology</td>
<td>-0.022</td>
<td>0.962</td>
<td>0.065</td>
<td>-0.149 - 0.106</td>
<td>0.080</td>
<td>221</td>
<td>0.737</td>
</tr>
<tr>
<td>Engineering</td>
<td>-0.051</td>
<td>0.974</td>
<td>0.066</td>
<td>-0.181 - 0.080</td>
<td>-0.762</td>
<td>215</td>
<td>0.447</td>
</tr>
<tr>
<td>STEAM Career</td>
<td>0.041</td>
<td>0.526</td>
<td>0.036</td>
<td>-0.029 - 0.112</td>
<td>1.155</td>
<td>214</td>
<td>0.249</td>
</tr>
</tbody>
</table>

Note. *Statistically significant at $p<0.001$ level. The pre-surveys were subtracted from the post-surveys to make understanding the differences intuitive. The positive mean difference is growth between pre-survey and post-survey, and the negative mean difference is a decline in interest. The degrees of freedom vary due to missing data.

Discussion

The garden-based learning approach and having a STEAM projects course available at the school did have some effect on individual STEAM career interests. There was a statistically significant increase in the middle grades students’ science career interests, including female and students of color in similar ways to the whole group. This result counters research that positive attitudes towards science and science careers identified in youth at age 10 sharply declined by age 14 (Morrell & Lederman, 1998; Tai et al. 2006). These positive results most likely occurred because of the STEAM garden-based program which engaged students in STEM content in a meaningful authentic way. All students and teachers at the school have access to the school garden, additionally, there is a garden club of volunteer teachers and students, who maintain and care for the garden. The garden club created posters, outreach pictures of things that have been done in the garden, and helpers in the garden on the school TV announcements.
The mathematics subject and career interest were high in pre-survey and post-survey for the whole school, but not significantly different in pre-survey and post-survey for any group, this is still better than the result from Frenzel at al., (2012) which showed mathematics interest to significantly decrease during the middle school years. For the STEAM garden-based program, students were engaged with mathematically foregrounded projects, including garden-based scale drawings (authors, 2022), nature journaling, companion planting lessons, storytelling (authors, 2022), and compressed-air rocket building and mathematically modeling the path of the launch (author, 2023). All these projects allowed students to engage with their mathematics interests because they are able to apply it to the real world.

**Significance**

There is a need for more students to go into high-paying STEM careers (Dorssen et al., 2006; Torlakson, 2014; Varas, 2016) Students in the study’s age group (12 to 15 years old) have been previously shown to show less interest in science and mathematics careers than when they were younger (Morrell, & Lederman, 1998). This study showed that it is possible to reverse this trend by adding a school garden that is used by teachers at the school and by offering a STEAM Projects course. This study showed that engagement in science and through an interdisciplinary approach, that included the arts holds promise for increasing interest in STEM careers for middle grades students. The STEAM garden-based program maintained or increased students’ interest in STEAM careers during this crucial developmental period. Perhaps, the addition of art in STEM (Lin and Tsai, 2021; Morrell & Ledermann, 1998), and engagement in gardening was the key. Our results supports previous research, which links science learning to the integration of the arts (Hardiman et al., 2017). This research has identified encouraging promise of school gardens and art integration in STEM, especially for science career interests. Perhaps the students in the garden club developed a sense of belonging, which they loved to share with their peers. When students created STEAM projects, the integration of the art made it more personal for the students. This also aligns with the SCCT, which links students’ personal experiences and contextual supports to predict their STEM career interests.

The gains made by teaching science in a more integrated way within a context a school garden and with the integration of all the STEAM subjects may be of interest to education researchers, policymakers, and STEM teachers. Recommendations for using these results include providing students with opportunities to engage in integrated STEAM projects, in addition to full stand-alone subject-specific STEAM courses, and a school garden. This empirical evidence agrees with Williams et al., (2018) in that it supports involving middle school students in authentic, real-world endeavors that have personal relevance to engage and cultivate their interest in science and science careers, and by extension STEM careers.
References

Authors (2022).
Authors (2023).
Authors (2023).

