Invention Education Programming: Perceptions of Children and Teacher-Facilitators

A Technical Report prepared for Camp Invention®

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Executive Summary

Camp Invention® provides out-of-school time summer enrichment programs for K-12 students with the aim of both strengthening and diversifying the domestic STEM and invention pipeline. This study builds on prior research (Garner, Matheny, Rutledge & Kuhn, 2021) as well as extant literature on the factors that support STEM motivation and persistence in underrepresented students to investigate children's perceptions of camp programming and teachers' suggestions for supporting culturally and economically diverse camp participants.

The study addressed three research questions: RQ1. To what extent do children perceive themselves to have an inventive mindset and identify with STEAM subject areas, and does participating in Camp Invention® experiences impact these self-perceptions? RQ2. To what extent is Camp Invention® programming perceived by children to be supportive of their learning in STEAM and invention, and do these perceptions vary by gender and race-ethnicity? RQ3. To what extent are facilitators prepared to provide multicultural or culturally responsive experiences during Camp Invention® programming?

Data were collected in several waves over the summer and fall of 2021. Two samples of children (n=212, n=108) completed pre-camp and post-camp surveys. Two samples of camp facilitators (n=138, n=119) completed post-camp and school year surveys. Descriptive and inferential statistics were used to analyze quantitative data pertaining to children's self-perceptions of inventive mindset, identification with STEAM subject areas, and ratings of camp activities, as well as facilitators' perceptions of preparedness to support culturally diverse groups of students. Qualitative data were analyzed inductively using a process of thematic analysis by one researcher with auditing by a second researcher.

In brief, children had relatively strong inventive mindset self-ratings at pre-camp and post-camp, and these did not vary significantly by gender or race-ethnicity. Identification with STEAM subject areas was also consistent from pre-camp to post-camp, but was subject to gender effects at both time points and a gender by race-ethnicity group interaction at the pre-camp time point. Inventive mindset was moderately correlated with identification with STEAM subject areas; at post-camp, the correlation between inventive mindset and engineering became stronger, particularly for non-White students, but weakened for math across all groups. At the post-camp time point, but not at the pre-camp time point, non-White students more strongly self-identified as "inventive" than White students. As a group, children felt more confident and happier while doing most-liked activities, and also felt that these were more useful and lent themselves towards new learning compared to least-liked activities. There were no gender or racial-ethnic group differences in children's decisions about most-liked or least-liked activities, with making/creating/building being the most liked activity and sharing ideas with others being the least-liked activity. However, an analysis of children's responses for why they had indicated sharing as their least liked activity revealed a relative preponderance of social anxiety among non-White students.

When asked, a large proportion of facilitators felt that Camp Invention® programming was adequately responsive to children of diverse backgrounds, but they were able to list possible strategies for increasing participation of children from underrepresented and economically disadvantaged groups. Facilitators demonstrated some confusion between strategies that are aligned with multiculturalism and those aligned with culturally responsive teaching. As a group, perceptions of preparedness to work with students from diverse backgrounds was significantly correlated with years of teaching experience, but not years of experience as a Camp Invention® facilitator.

The generalizability of these findings is somewhat limited due to the small, self-selected samples of respondents, and the relative lack of racial-ethnic diversity among the children and facilitators. However, the results provide a rationale for larger scale efforts to examine the ways in which Camp Invention® programming can support students from diverse and economically disadvantaged backgrounds.

Introduction

Recent calls for diversifying the invention pipeline have resulted in increased attention to the ways K-12 invention education programming can support underrepresented groups, including females and students of color. In this study, we examined children's perceptions of various aspects of Camp Invention®, a national model for out-of-school time enrichment in STEM and invention. The study builds on prior work that examined Camp Invention® programs as a context in which students could explore their self-perceptions of inventiveness and their identification with STEM subject areas (Garner, Matheny, Rutledge & Kuhn, 2021), by investigating how camp programming is perceived by students of different genders and racial-ethnic groups. To complement the student data, this research also examined teachers' perceptions of the degree to which Camp Invention® programs are supportive of culturally responsive teaching practices, which have been shown to benefit the STEM confidence, motivation, and performance of underrepresented students (Gay, 2013). Since little is known about students' and teachers' perceptions of educationally inclusive practices in invention education in particular, the findings of this study are relevant to practitioners and scholars alike.

Background

Because formal K-12 curricula largely overlook the opportunity to develop students' capacity for invention and innovation, out-of-school time invention education programs often provide children with their first exposure to concepts such as problem finding, prototyping, and pitching ideas to others. This type of curricular enrichment may be particularly beneficial for students whose social identities are historically underrepresented in the STEM and invention pipeline, including females, students from racial-ethnic minority groups, and those from economically disadvantaged backgrounds. As a population, children in economically

disadvantaged or culturally diverse communities are more likely to attend school systems that do not routinely offer experiences in making, design, and invention. These children may also lack role models and local support systems that help them to imagine a future where they are participants in the invention and commercialization sectors of the economy (Bell, Chetty, Jaravel, Petkova, & Van Reenen, 2018).

Camp Invention® is a national organization that provides invention education experiences to elementary and middle school students through camps and summer enrichment programs. The curriculum supports children as they draw on knowledge and skills in science, technology, engineering and mathematics (STEM), and does so through hands-on, design-based challenges and activities. Prior research in the camp context has demonstrated that participants do perceive particular features of the camp programming as being supportive of the development of their inventive mindsets and identification with STEM subject areas, which suggests that invention education programming may act as a context for children to strengthen their intentions towards staying in the STEM and invention pipeline (Garner, Matheny, Rutledge, & Kuhn, 2021). However, this research did not focus on whether perceptions of the camp vary depending on the participants' gender and racial-ethnic groups, and whether camp facilitators feel adequately equipped to respond to the diverse cultural backgrounds of participants. Therefore, in parallel to investigating the perceptions of diverse camp participants, this research examines facilitators perceptions of cultural responsiveness.

Culturally responsive teaching can be defined as "using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them.'" (Gay, 2013, p. 49-50). Bringing culturally responsive approaches into the classroom or camp context may look different in different settings, but it could include increasing relevance by incorporating local issues into design challenges or drawing on culturally familiar experiences, or increasing students' sense of cultural capital and sense of belonging by bringing in role models who have similar backgrounds to their own. The intersection of invention education and culturally responsive pedagogies has not received a great deal of attention, but it offers the opportunity for researchers and practitioners to learn more about what works, for whom, and under what circumstances.

Research Questions

This research sought to investigate the following three questions:

1. To what extent do children perceive themselves to have an inventive mindset and identify with STEAM subject areas, and does participating in Camp Invention® experiences impact these self-perceptions?
2. To what extent is Camp Invention® programming perceived by children to be supportive of their learning in STEAM and invention, and do these perceptions vary by gender and race-ethnicity?

3. To what extent are facilitators prepared to provide multicultural or culturally responsive experiences during Camp Invention® programming?

Methods

Participants

We invited children who were enrolled in Camp Invention® programming during the summer of 2021 to complete a survey before and after their experiences. At the pre-camp time point, *N* = 212 complete responses were obtained from *n*=91 females and *n*=121 males. Participation from non-White racial-ethnic groups was low, leading to a dichotomous grouping for analytical purposes (*n*=145 White, *n*=54 non-White). At the post-camp time point, *N* = 107 complete responses were obtained from *n*=47 females and *n*=60 males.

The analytical sample includes the 107 matched responses from children who completed the surveys at both the pre- and post-camp time points. The analytical sample age distribution was as follows: 8 years old (*n*=7, 6.5%), 9 years old (*n*=26, 33.3%), 10 years old (*n*=41, 38%), 11 years old (*n*=21, 19.4%), 13 years old (*n*=1, 0.9%) and undefined (*n*=*2*, 1.9%). The most frequent grade level the students would be attending in the fall was fifth grade (*n*=40, 37%) followed by fourth grade (*n*=36, 33.3%), then sixth grade (*n*=25, 23.1%), seventh grade (*n*=1, 0.9%) and undefined (*n*=6, 5.6%). Parents indicated their child's racial-ethnic group. Most of the group was White (*n*=79, 73.1%). A small number (*n*=10, 9.3%) identified as Black or African American, *n*=5 (4.6%) as Hispanic or Latino, *n*=3 (2.8%) as Asian, and *n*=1 (0.9%) as American Indian or Alaskan Native. Ten children (9.3%) were identified as Two or more races. For the analyses, these groups were collapsed into the White and non-White categories. Approximately one-half of the sample indicated that they lived in Massachusetts (*n*=15, 13.9%), Ohio (*n*=10, 9.3%), Wisconsin (*n*=10, 9.3%), Maryland (*n*=8*,* 7.4%), or Michigan (*n*=8, 7.4%). Twenty eight other states reported 7 or fewer participants.

To address the third research question, we gathered responses from a sample of Camp Invention® facilitators at the conclusion of the summer and during the school year. At the conclusion of the summer programming, all facilitators were invited to participate, and *n*=138 chose to do so. Demographic information was not gathered at this time point. Then, at the end of the first quarter of the school year, a follow up survey was made available to facilitators, and *N*=119 participants provided responses. At this time point, demographic data were collected. The majority of the respondents identified as White (n=110; 92.4%), with a small percentage identifying as Black or African American (n=3, 2.5%), Hispanic or Latino (n=3, 2.5%) or Two or more races (n=3, 2.5%). The sample was mostly female (n=107, 89.9%) and minority male (n=11, 9.2%). One respondent declined to identify their gender. The sample had a mean age of 49 years (SD=10.54). Participants reported an average of 17.84 years of teaching experience (SD = 9.22). Few respondents were first time CI facilitators; the mean number of years of CI facilitation experience was 3.64 (SD=3.52). The majority of the respondents (n=113, 95%)

conducted in-person CI programming. Most of the teachers (n=107, 90%) were engaged in in-person teaching at the time of their response, with a small number of teachers reporting that they were teaching using a hybrid format (n=8, 7%). Four respondents indicated that they had retired or were otherwise not teaching. The majority of teachers indicated that they were teaching "multiple" grade levels (43.8%), suggesting that they were subject area experts. A large proportion of the rest of the participants were either teaching 5th grade (12.4%) or second grade (10.5%).

Procedure

Following approval from the Old Dominion University Institutional Review Board, email invitations to participate were sent to parents who had enrolled their children in Camp Invention®. Parents completed an informed consent form, and then children completed the online pre-camp survey. Upon completion of their camp participation, enrollees were sent an invitation to participate in the only post-camp survey.

Parents provided informed consent and also indicated their child's race-ethnicity and geographical location. The pre-camp survey gathered demographic data from the children including gender, age, and grade level. The survey included the *Inventive Mindset* measure and items that asked children to rate their identification with science, technology, engineering, arts, and mathematics (STEAM). The post-camp survey repeated the inventive mindset and STEAM identification items, and included several items that asked for Likert scale ratings of the child's most and least liked activity according to features of contexts that have been shown to support STEAM and inventive identity exploration (Garner, Matheny, Rutledge, & Kuhn, 2021): perceived happiness, perceived confidence, perceived usefulness, and perceived novelty during learning.

Separately, camp facilitators were invited to participate in the research study. The emphasis of the online post-camp survey was on facilitators' own inventive mindsets and the ways in which they could foresee transferring camp curricula into their classrooms during the school year. These data are included in a separate report. One post-camp survey item was used: In your opinion, what would make invention education programming more responsive?

The school-year facilitator survey included questions pertaining to the transfer of camp curricula and instructional strategies, but also included a four point Likert scale question:

- To what degree did you feel that Camp Invention prepared you to teach invention concepts to students of diverse cultural and economic backgrounds?
  It included an open ended question:
- What strategies could Camp Invention use to attract and retain students from diverse cultural and economic backgrounds?
  It asked for a rating on a scale of 0-100% on the following two items:
- The degree to which the Camp Invention curriculum includes the following design features. - Culturally responsive: The curriculum uses the cultural knowledge, prior

experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant for them.

- The degree to which the Camp Invention curriculum includes the following design features. - Multicultural: The curriculum includes cultural pluralism or diversity.

Data analysis

Cases for which informed consent could not be verified were removed prior to data analysis.

Quantitative data. Quantitative data were analyzed using SPSS 28.0 for Windows. Complete, matched cases of children's data were then subjected to standard descriptive and inferential statistical analyses including measures of central tendency and dispersion, paired and independent t-tests, Chi-square tests, and analysis of variance depending on the nature of the data and the research question. The *Inventive Mindset* measure was also subjected to internal consistency reliability analysis, and yielded Cronbach's alpha of .731 at pre-camp administration (n=275), and .752 at post-camp administration (n=108).

Qualitative data. Inductive and thematic analyses with auditing were used to code students' and teachers' open-ended responses (Zhang & Wildemuth, 2009). Students' responses were reviewed in SPSS and then inductively coded into themes that captured the full range of topics for a particular question. In a second step, teachers' responses were then systematically analyzed and sorted into one of eight categories and visualizations were created. Illustrative responses were identified for inclusion in the report.

Results

RQ1. To what extent do children perceive themselves to have an inventive mindset and identify with STEAM subject areas, and does participating in Camp Invention® experiences impact these self-perceptions?

Children rated themselves on the ten items of the *Inventive Mindset* measure using a four point Likert scale. At the pre-camp time point, there were no differences in children's responses to the *Inventive Mindset* measure by race-ethnicity as categorized by White and non-White, $t_{(197)} = 0.34$, $p>0.05$. There were also no differences by gender, $t_{(210)} = 0.46$, $p>0.05$. Table 1 provides pre-camp inventive mindset scores by gender and race-ethnicity. Children embarked upon their camp experiences without pre-existing differences in self-perceptions that were associated with their gender or racial-ethnic minority status.

A subset (n=107) of the children who responded at the pre-camp time point also completed the post-camp survey. As a whole group, the difference in the inventive mindset total score at the post-camp time point approached statistical significance, $t_{(106)}=-1.77$, $p=0.08$. Table 2 presents descriptive statistics for the matched sample.

Table 1. Pre-camp Inventive Mindset by minority and majority race-ethnicity categories.

	Pre-camp Inventive Mindset Total Score	
	Mean	Std. Dev.
Female (*n*=91)	33.40	3.61
Male (*n*=121)	33.17	3.65
White (*n*=145)	33.40	3.45
Non-White (*n*=54)	33.20	4.06

Table 2. Inventive Mindset scores at pre-camp and post-camp.

	Pre-camp		Post-camp	
	Mean	Std. Dev.	Mean	Std. Dev.
I am open to new ideas	3.26	0.52	3.37	0.65
I give up easily (reversed)	3.14	0.59	3.20	0.61
I am a problem solver	3.30	0.62	3.41	0.51
I like to design things	3.57	0.68	3.61	0.56
I have lots of good ideas	3.47	0.54	3.49	0.57
I am imaginative	3.61	0.58	3.63	0.57
I like to share my ideas with others	3.23	0.62	3.09	0.73
I am creative	3.62	0.54	3.58	0.56
I like to make things better	3.40	0.61	3.44	0.59
I am inventive	3.45	0.59	3.39	0.59

Total score	33.86	3.43	34.24	3.31

We examined pre- and post-camp changes in inventive mindset total scores by gender and race-ethnicity group using multivariate analysis of variance. There was no main effect of gender, $F_{(1,106)}=0.5$, $p>0.05$, or race-ethnicity, $F_{(1,106)}=1.93$, $p>0.05$, on pre-camp total scores, and no main effect of gender, $F_{(1,106)}=2.5$, $p<0.05$ on post-camp total scores. There was a marginally significant main effect of race-ethnicity on the post-camp total scores, $F_{(1,106)}=3.95$, $p=0.05$. There were no statistically significant interaction effects. Although small in overall magnitude, the inventive mindset gains from pre-camp to post-camp were more pronounced for non-white students, regardless of their gender (Table 3).

Because of our focus on children's perceptions of invention and inventiveness, and whether this differed according to membership of a group that has historically been underrepresented in invention, we conducted single item independent t-tests on pre- and post-camp responses to the item "I am inventive." There were no differences at the pre-camp time point, and no post-camp time point differences for gender, but there was a statistically significant difference for the race-ethnicity groups. Non-White students rated themselves on the "I am inventive" item more highly than White students at the post-camp time point, $t_{(106)}=-2.13$, $p<0.05$. The mean rating for non-White students was 3.59 (SD = 0.50) and 3.32 (SD = 0.61) for White students. This is a relatively small difference but is worthy of further research.

Table 3. Mean inventive mindset scores for White and non-White participants

	Pre-camp response		Post-camp response	
	Mean	Std. Dev.	Mean	Std. Dev.
White group (*n*=78)	33.76	3.19	33.91	3.40
Female (*n*=31)	34.00	2.99	33.10	3.78
Male (*n*=47)	33.60	3.34	34.45	3.05
Non-White group (*n*=29)	34.13	4.04	35.14*	2.90
Female (*n*=16)	34.44	4.08	34.75	2.27
Male (*n*=13)	33.77	4.13	35.62	3.57

* $p\leqslant 0.05$.

Further analysis of the matched cases revealed no significant relation between age and inventive mindset at either the pre-camp time point, $r_{(107)}=-0.03$, $p>0.05$, or the post-camp time point, $r_{(107)}=-0.04$, $p>0.05$, meaning that inventive mindset scores were not systematically higher

or lower for younger or older children. Pre-camp and post-camp inventive mindset scores were significantly correlated with one another, $r_{(107)}=.41$, $p<0.001$.

Children rated their identification with the five STEAM subject areas that are closely aligned to the Camp Invention® curriculum. Pre-camp and post-camp responses are shown in Table 4 below.

Table 4. STEAM identification scores at pre-camp and post-camp

	Pre-camp		Post-camp	
	Mean	Std. Dev.	Mean	Std. Dev.
I am a math person	2.92	0.93	2.86	0.97
I am a science person	3.19	0.71	3.16	0.71
I am an engineering person	2.99	0.77	3.22	0.78
I am an arts person	3.14	0.75	3.32	0.78
I am a technology person	3.50	0.68	3.44	0.60
Total score	15.98	1.97	16.00	2.22

Analysis of variance revealed statistically significant differences in STEAM identification total score at pre-camp and at post-camp. At pre-camp, there was a main effect of gender, $F_{(1,106)}=5.73$, $p<0.05$, in favor of males, and a gender x race-ethnicity interaction, $F_{(1,106)}=4.06$, $p<0.05$ that originated from a statistically significant difference between White and non-White girls at pre-camp (with non-White girls scoring higher). At post-camp, the main effect of gender remained, $F_{(1,106)}=5.62$, $p<0.05$ but the gender x race-ethnicity interaction was no longer statistically significant. Table 5 presents descriptive statistics for STEAM identification scores by gender and race-ethnicity at the pre-camp and post-camp time points.

Table 5. Identification with STEAM at pre-camp and post-camp by gender and race-ethnicity

	Pre-camp STEAM Identification		Post-camp STEAM Identification	
	Mean	Std. Dev.	Mean	Std. Dev.
White Females (*n*=31)	14.87	1.43	14.94	2.06
Non-White Females (*n*=16)	16.00*	2.23	16.13	2.50

All Females (*n*=47)	15.26**	1.82	15.34	2.27
White Males (*n*=47)	16.66	1.85	16.42	1.98
Non-White Males (*n*=13)	16.15	2.15	16.85	2.27
All males (*n*=60)	16.55**	1.90	16.47	2.05

* This was statistically significantly higher than White females at the pre-camp time point.
** The gender difference was statistically significant at the pre-camp and post-camp time points.

Compared to their pre-camp responses, children's post-camp inventive mindset was more strongly associated with their identification with science, technology, engineering, the arts, and mathematics. Table 5 presents the bivariate correlations between inventive mindset total score and identification with STEAM subjects at the pre- and post-camp time points for the whole group as well as for the gender and race-ethnicity subgroups.

Table 5. Correlations between inventive mindset and identification with STEAM subject areas.

	Identification with STEAM subject ("I am a ____ person")				
	Math	Science	Art	Engineering	Technology
Pre-camp					
All (*n*=107)	.20*	.26**	.26**	.38*	.10
Female (*n*=47)	.20	.27	.21	.44**	-.03
Male (*n*=60)	.22	.31*	.27*	.50**	.28*
White (*n*=78)	.21	.23*	.21	.41**	-.01
non-White (*n*=29)	.19	.33	.33	.32	.33
Post-camp					
All (n=108)	.04	.26*	.26*	.38**	.10
Female (*n*=47)	.06	.18	.18	.24	.06
Male (*n*=61)	.05	.29*	.39**	.33**	.25
White (*n*=78)	.04	.29*	.24*	.29*	.15

non-White (*n*=29)	.05	.20	.27	.48**	.28

* p<0.05 * p<0.01

Across all groups and subgroups, the strongest correlations were between inventive mindset and identification with engineering. The correlations between inventive mindset and identification with math weakened at the post-camp time point for all respondents, while the correlation between inventive mindset and engineering strengthened for the non-White group and became statistically significant.

RQ2. To what extent is Camp Invention® programming perceived by children to be supportive of their learning in STEAM and invention, and do these perceptions vary by gender and race-ethnicity?

In the post-camp survey, the students provided their perceptions about the most and least liked activities. A total of 108 children rated their most and least liked activities, and 106 children provided specific details about them.

Table 7. Children's most liked activities

	Number of responses for each activity			
	Making/Creating/ Building	Thinking up new ideas	The Coaching session	Sharing my ideas
All (*n*=108)	98	6	1	1
Female (*n*=47)	40	3	1	1
Male (*n*=61)	58	3	0	0
White (*n*=78)	74	2	1	1
non-White (*n*=28)	24	4	0	0

Chi-square tests on the whole group's responses revealed that the distribution of preferred activities was statistically significant, $X^2_{(3)}$=257.85, p<0.001, but it was not dependent on gender $X^2_{(3)}$=2.96, p>0.05 or race-ethnicity, $X^2_{(3)}$=5.90, p>0.01. This was also the case for the least preferred activities, $X^2_{(3)}$=47.87, p<0.001, which were also not dependent on gender, $X^2_{(3)}$=2.07, p>0.05 or race-ethnicity, $X^2_{(3)}$=1.87, p>0.05.

Table 8. Children's least liked activities

	Number of responses for each activity			
	Making/Creating/ Building	Thinking up new ideas	The Coaching session	Sharing my ideas
All (*n*=106)	2	15	41	43
Female (*n*=43)	0	7	16	20
Male (*n*=58)	2	8	25	23
White (*n*=79)	2	32	33	32
non-White (*n*=27)	0	5	8	24

Using a four point scale, children were asked to rate how they felt while engaged in their most and least liked activities. Overall, the total rating for the most and least liked activities differed significantly (Table 7), $t_{(108)}=3.23$, $p<0.000$. When paired t-tests with Bonferroni corrections were conducted to examine ratings of specific task perceptions, these were also significant. Participants felt significantly more confident, $t_{(106)}=12.68$, $p<0.001$ and happier $t_{(106)}=14.24$, $p<0.001$ when completing most liked over least liked activities, rated their most liked activity as more useful than their least liked activity $t_{(106)}=-15.54$, $p<0.001$, and rated their most liked activity as involving learning something new, $t_{(107)}=-2.53$, $p=0.01$. Analysis of variance revealed that there were no significant differences in total ratings of most liked or least liked activities according to gender or race-ethnicity. Together, these results suggest that overall, most liked activities were rated higher than least liked activities for positive emotions such as confidence and happiness, usefulness, and novelty.

Table 9. Emotions and perceptions associated with most and least liked activities.

	Least liked		Most liked	
	Mean	Std. Dev.	Mean	Std. Dev
Felt confident	2.53	0.83	3.64*	0.52
Felt happy	2.51	0.87	3.73*	0.53
Activity was useful	1.46	0.58	3.02*	0.71
Activity allowed	1.69	0.78	1.93*	0.76

for new learning				
Total	9.86	1.88	10.51*	1.09

* Statistically significant difference, p⩽0.01.

Children provided reasons for their most and least liked activity. Their responses were coded thematically. Children's reasons for their most liked activity included having fun and enjoying the activity, e.g. "It is fun to build new things," being creative, e.g. "I could create things and come up with new ideas," and being able to spend time on hands-on projects, e.g. "It is hands-on and I can play around with the models I create."

Despite homogeneity in children's reasons for their most liked activities, a trend emerged in children's ratings of least liked activities. Sharing ideas with others was the highest frequency "least liked" activity. When coded thematically, 34 out of 47 (72%) of the responses indicated the presence of social anxiety. Children made comments such as "I don't like talking in public," "I don't like talking in front of people I don't know," and "I do not feel comfortable in front of people." Responses such as these were found in approximately equal proportions across genders, but were more noticeably more common in non-White students. The likelihood ratio for race-ethnicity was 4.23, which was significant ($p<0.05$). Table 10 presents the frequencies of social anxiety-related responses for gender and race-ethnicity.

The presence of social anxiety as a reason for children's least liked activity

	Theme of social anxiety	
	Not present	Present
All who provided a response (*n*=47)	13	34
Females (*n*=23)	5	18
Males (*n*=24)	8	16
White (*n*=34)	12	22
non-White (*n*=13)	1	12

As can be seen from the table, the responses of 50% of the White children included a reference to social anxiety, but the responses from 92% of the non-White children reflected this theme. The sample size is small and the results should be treated as preliminary, but the finding suggests that although they were no more likely than White children to identify sharing ideas as a least liked activity, non-White children were more likely to indicate social anxiety as the reason

for not liking the sharing activity than their White peers. This is one way in which the Camp programming may have been perceived differently based on students' status as a member of a historically underrepresented group.

RQ3. To what extent are facilitators prepared to provide multicultural or culturally responsive experiences during Camp Invention® programming?

Post-camp survey. Of 138 teacher responses to the entire survey, 90 teachers provided a written response for the question: "In your opinion, what would make invention education programming more culturally responsive?" Some teachers' responses indicated confusion with the terminology *"culturally responsive."* In many cases, responses reflected the concept of multiculturalism, which is best understood as exposure to a diverse range of experiences and backgrounds[1]. After codes were assigned, individual responses were again investigated for a common theme that seemed to emerge with the first round of coding: misunderstanding with of the term "culturally responsive" as prompted in the question and insertion of the definition of multiculturalism: "cultural pluralism or diversity (as within a society, an organization, or an educational institution)" (Merriam-Webster, 2021). A second round of coding was conducted with categories that identified responses as either referring to multiculturalism, clearly referring to culturally responsive teaching, somewhat suggestive of culturally responsive teaching, or inadequate data to categorize.

Theme 1. Uncertainty on improvement or contentment with current programming. A plurality of teachers (42.2% of valid responses) expressed sentiment that indicated they either did not know, could not think of, or had no suggestions for improvement of the cultural responsiveness of CI's programming. However, the vast majority of these responses were short, such as "I don't know" or "Unsure" or "Fine as is". Few in-depth responses included this sentiment.

Theme 2. Visibility and modeling with program content. Several teachers (23.3% of all valid responses) suggested that a portion of camp programming at present involves videos that show diverse inventors from different countries. Some responses indicated added emphasis on Black and Indigenous people of color (BIPOC), LGBTQ+ individuals, and women in invention in this subset of programming would add to current endeavors to broaden representation in curriculum. One teacher wrote,

> "Including more role models from different backgrounds, genders, socioeconomic status, etc. so students can see people from all backgrounds being successful and how they worked to get where they are."

[1] While multiculturalism has its benefits for all students through exposing students to diverse experiences, culturally responsive teaching is designed to provide students from minoritized backgrounds with an equitable experience that compensates for systemic disadvantages.

Other teachers raised the question of including inventors from other countries and cultures. One wrote,

> "Including inventors from other countries as well--I read a lot about US patents and US inventors this summer but was asked by a lot of kids about the systems in Canada or the UK."

Another commented,

> "…having different people from around the world be represented. If something was invented in China, was something similar invented in Italy? Does it have a specific function that is only relative that a particular culture or people group? Or if something we use a lot of was invented in another country, that would be really neat to highlight."

It is important to note that adding *more* role models from around the world is not necessarily within Gay's definition of culturally responsive teaching (CRT) unless students participating have personal connections to the featured ethnicities and nationalities (2013).

Teachers generated strategies for improving the reach of Camp Invention ® to underrepresented and economically disadvantaged students. The strategies fell into three themes, as follows.

Theme 3. Outreach and recruiting of more diverse students. Several teachers (12.2% of all valid responses) suggested strategies and means of attracting students from underrepresented and/or economically disadvantaged backgrounds. Some of these suggestions included multiple language options for advertisements and take-home paperwork (especially with English language learner communities) and low-income accessible price structuring or scholarship opportunities for students from poor communities. For example, one teacher commented,

> "I believe with the scholarships awarded and discounts, all students have a chance to attend. If this is a false belief, then maybe more scholarships for students in need."

Another wrote,

> "I LOVE that you are asking this! In our area, it is the cost that is prohibitive to students and their families. (In other words, it is all the affluent, white families that are registering.) It would also be helpful to get Spanish language handouts for parents with any sort of cost support."

A third example of outreach focused on the location of the camps. The teacher wrote,

> "Both camps that I worked in were not in the most culturally diverse community. Have camps within walking distance of culturally diverse areas of our community would make it easier for those students to have access to the camp."

Theme 4. Relevance and Support systems. Several teachers (11.1% of valid responses) indicated suggestions for making content and experiences more relevant to students from diverse backgrounds as well as ways to address specific support needs of students from diverse backgrounds. Examples include cohorts of cultural groups to foster confidence, focus on specific environmental issues from local communities, and careful consideration for the home life of economically disadvantaged students when designing take-home activities. One teacher wrote,

> "A more culturally responsive program would offer " a taste" of the camp activities in small cultural groups during the school year. so they can become confidant [sic] about their abilities to be in this type of camp."

Another teacher commented,

> "While CI does a tremdnous [sic] job exposing children to diverse inventors, building more of the activities around diverse cultures and environments would be great."

Teachers also connected the need for resources for students of economically disadvantaged backgrounds. One wrote,

> "Less reliance on bringing things from home. Some households don't have enough so there was a definite disparity in that regard. We quickly ran out of supplies and had to dismantle things at the end of each session to ensure there was enough for other groups."

Theme 5. Teacher training. A small number of teachers (4.4% of valid responses) suggested more in-depth training with educators to address subconscious biases and gaps in understanding of how to provide culturally relevant experiences for students. One wrote about the need for teachers to understand diverse students experiences, saying

"Today the child's home life is very different and we as teachers need to make sure we know the differences and diversity of the student. I think this program opens up a lot of eyes to the opportunities that are out their [sic] in STEM."

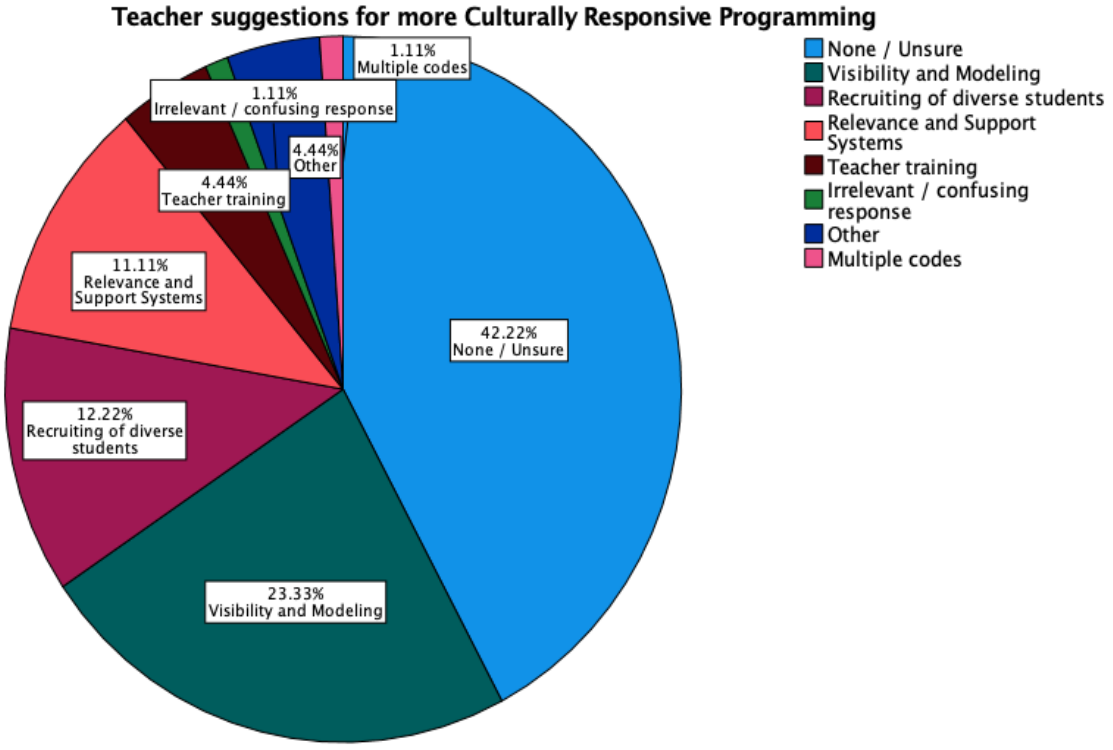
While this was a fairly small subset of responses, the noted confusion with the terms *multiculturalism* and *culturally relevant* among many responses may support a need to increase teacher training in the development of culturally responsive lessons and learning environments. Figure 1 provides a visual representation of the various themes.

Teachers' strategies for recruiting diverse and economically disadvantaged students

In the school year survey, teachers were asked how well prepared they felt by Camp Invention® to teach invention concepts to students of diverse cultural and economic backgrounds. All but one respondent (n=118) answered this question and the mean rating on a four-point scale of perceived preparedness was 3.09 (SD = 0.84). This was uncorrelated with the number of years of Camp Invention experience but positively correlated with the number of years of teaching experience (r=.28, $p<0.005$).

Teachers also had positive perceptions of the degree to which the Camp Invention curriculum includes culturally responsive design features, and multicultural design features. We defined culturally responsive design features as using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant for them. This was rated on a scale from 0 to 100, and the mean rating was 74.74 (SD = 21.47). We defined multicultural design features as including cultural pluralism or diversity. The mean rating on the 0 to 100 scale was 73.42, (SD = 24.09).

Figure 1. Distribution of all response codes in teachers' responses.



Teachers' perceptions of preparedness to teach invention concepts to diverse students were positively correlated with their perceptions of cultural responsiveness ($r=.24$, $p<0.05$) and multiculturalism ($r=.24$, $p<0.01$). Ratings of cultural responsiveness and multiculturalism were highly correlated ($r=.83$, $p<0.01$).

In this survey, teachers were asked to provide open-ended responses to the question: What strategies could Camp Invention use to attract and retain students from diverse cultural and economic backgrounds? There were 119 unique responses, with 16 responses being double coded to include a secondary area of emphasis. The frequencies of the responses for each theme are shown in Table 11 below.

Table 11. Teacher generated strategies for attracting diverse students

	Frequency	Percent of total generated strategies
None/blank	32	24%
Doing enough	9	6%
Fiscal changes, e.g. scholarships,	39	29%

transportation, meals		
Language barriers (materials, teacher training)	4	3%
Curricular changes (general, relevance, modeling, multicultural)	25	19%
Advertising/location (placement of camps, material features)	15	11%
Community outreach (low SES, culturally diverse locations)	7	5%
Vague or unclear	4	3%
Total number of strategies	135	100

Discussion

The primary aim of this study was to investigate children's perceptions of invention education programming and place a particular emphasis on identifying any ways in which perceptions or experiences might differ by gender and race-ethnicity. A related goal of the research was to examine the perceptions of teachers, who, in the role of facilitator, implement invention education programming through Camp Invention®. The study is not intended to be interpreted as an evaluation of the impact of Camp Invention®. It does, however, point to some avenues for future research that could reveal more information about how invention education programming might reach and support students of color and students from historically marginalized and underrepresented groups, who as adults are noticeably absent from the invention and commercialization pipeline in the United States (Bell, Chetty, Jaravel, Petkova, & Van Reenen, 2018). Here, we provide a summary of the main findings of the study and discuss some implications for practitioners in the field. We close with limitations of the study and some recommendations for future research.

Inventive mindset and identification with STEAM subject areas

Our first research question focused on the way children perceived their own inventive habits of mind, and the degree to which they identified with the various STEAM subject areas. Generally, children saw themselves as inventive. They did not vary in their self-perceptions of inventiveness ahead of participating in Camp Invention, and we did not find evidence of any gender or race-ethnicity differences. After participating in the camp programming, some small but statistically significant differences emerged. Inventive mindset total scores increased in a manner that was more pronounced for non-white students, regardless of their gender. In addition,

as a group, the difference in non-White students' self-ratings on the item "I am inventive" was greater at the post-camp time point than their White peers.

Identification with STEAM subject areas was fairly consistent over time, including gender differences that were evident at pre-camp persisted to post-camp. At pre-camp non-White females had significantly higher self-ratings than their White peers, although this gap had closed by post-camp. Low to moderate correlations were found between inventive mindset and STEAM subject areas, with the strongest correlations with engineering and the weakest with math. Notably, the correlation between inventive mindset and engineering strengthened for non-White students compared to the pre-camp time point.

Overall, Camp Invention® programming was associated with a trend towards improved self-perceptions of inventive mindset qualities for all students, with slightly larger changes in inventive mindset scores and perceived identification as an inventive person for non-White students compared with their White peers. However, we recommend seeking replication of this finding in future research.

Children's perceptions of Camp Invention® programming

Our second research question concerned children's perceptions of the activities that they conducted while participating in Camp Invention®. There were very clear preferences in most and least liked activities. Children most liked the making/creating/building activities, and least liked sharing their ideas with others. Most-liked and least-liked activities were rated differently according to features that support identity exploration in a domain, such as perceived confidence, perceived happiness, perceived usefulness, and perceived novelty. This finding replicates other work by Garner, Matheny, Rutledge and Kuhn (2021) who found these differences in most-liked and least-liked activities among a sample of Camp Invention® participants in the summer of 2020. In the present study, we investigated whether the activities and their ratings differed according to gender and race-ethnicity, and found that they did not.

Children did differ by subgroup in the prevalence of social anxiety as the reason for not liking the activity of sharing their ideas with others. Whereas the responses of 50% of the White children were coded according to this theme, the responses of 93% of the non-White children manifested this theme. This difference also requires replication, but leads us to conclude that facilitators may wish to pay attention to factors that might increase children's perceived comfort level in the social context of the camp, and make efforts to support non-White students in particular so that they feel comfortable sharing their ideas with others.

Facilitators' awareness of multicultural and culturally responsive teaching strategies

The third research question addressed the topic of meeting the needs of diverse learners in invention education programming from the perspective of the facilitators. The sample of facilitators was overwhelmingly White but it included many highly experienced teachers. Facilitators' ratings of their own comfort level teaching diverse learners in invention education settings was relatively high and was correlated with their years of teaching experience rather than

their years of experience as a facilitator. This may point to additional professional development needs in those camp facilitators who are also relatively inexperienced teachers.

When asked initially about cultural responsiveness, many of the facilitators provided answers that were more aligned with multiculturalism, which exposes students to different cultures and backgrounds rather than specifically leveraging opportunities to support students from historically marginalized groups. Immediately after facilitating the camp program, nearly half of the facilitators reported that they did not think that additional steps could be taken. This dropped to approximately one quarter when a separate group of facilitators responded to a school year survey. Overall, when asked to provide examples of ways that the camp program could reach historically underrepresented or economically disadvantaged groups of students, teachers provided responses that attended to the location and affordability of the camp, the materials used by facilitators, and the provision of materials in languages other than English.

Seeking to improve the cultural responsiveness of Camp Invention's programming is a very specific goal. Culturally responsive approaches to learning are designed to address gaps students from minoritized backgrounds face as non-members of a dominant culture through tailoring an educational experience to their specific needs and contexts. This is quite different from multiculturalism and its goal of broadening exposure to a plurality of cultures. Where multiculturalism can help address and unteach subconscious bias in students, especially students from backgrounds with societal segregation (such as suburban affluent communities, as mentioned by one respondent) we are mindful that multiculturalism could also be detrimental to the goal of achieving a culturally responsive curriculum. A multicultural program could further isolate students arriving with systemic disadvantages by presenting issues and examples that are further from home than a typical dominant culture curriculum. We highlight this possibility because of the teachers' uniform recommendations that both could be used to improve outcomes for underrepresented and minoritized students.

Limitations

Although this study provided an insight into the perceptions of children and facilitators who participate in invention education through Camp Invention® programming, there are some important limitations to note. The first is that the sample size of both children and facilitators is small compared to the overall number of participants involved in Camp Invention programming during the summer of 2021, and the demographic information and ratings provided by the samples may not be representative of the larger group. A second, related limitation is that the number of non-White children and facilitators in the samples is very small. It would not be appropriate to generalize the findings to all participants and facilitators of color, and further research is needed to extend the reliability and validity of this finding. Third, the numbers of non-White students were sufficiently small as to warrant combining them into one group for comparison with the White students. This unfortunately carries an assumption that the group is relatively homogenous in perceptions, which may not be the case. The researchers do not wish to make the claim that the non-White students' racial-ethnic groups should be interpreted this way.

A fourth limitation is that the data cannot be triangulated by information about the degree to which children actually participated in camp programming. Attendance data was not part of the data set, and we have no way to verify the degree to which children were engaged in the activities.

Recommendations

Based on the findings, we present two main recommendations for programming, one for facilitator professional development, and one for systemic growth in serving particular communities. First, camp curriculum coordinators may wish to examine the ways in which activities such as sharing ideas with others are presented to children and facilitated by staff. Children were less likely to feel confident and happy during this and other "least liked" activities than during their most liked activities. Although sharing ideas is an important part of STEM, design, and invention, there may be social or classroom management techniques that could be used to increase children's comfort level with this part of the camp curriculum. When attending to this aspect, we recommend drawing on culturally responsive pedagogies to foster inclusiveness for non-White students, since a much higher proportion of this group indicated that they felt some degree of social anxiety during this activity.

A second recommendation is to increase the degree to which STEAM subject areas are explicitly called out during camp activities. The strength of the correlation between children's identification with math and inventive mindset weakened from pre-camp to post-camp. This could be due to a relative lack of math-based activities, but it could be due to children not having experiences that explicitly connect mathematics with inventiveness.

Our third recommendation is to consider providing training for facilitators in both multiculturalism and culturally responsive pedagogies, and to develop and field-test specific strategies that might benefit students from economically disadvantaged or historically marginalized populations. Finally, our fourth recommendation is to examine the needs of particular populations who might participate in camp programming in various locations, and allocate resources accordingly. This might include developing materials for parents and facilitators that are in languages other than English, or allocating additional resources so that children from all economic backgrounds can access the camp and have sufficient resources to complete the activities.

Future research

The critical mission and cross-curricular emphasis of Camp Invention® lends itself to formal examination by the research community. One avenue for future research is to conduct a study that is aligned to the What Works Clearinghouse criteria for evidence of efficacious educational interventions. Typically, such studies involve a randomized control trial design where children would be randomly assigned to a treatment or control condition. For example, students could be assigned to either "business as usual" for summer or school year STEM programming, or Camp Invention® STEM and Invention Education programming. A rigorous

evaluation study would examine the fidelity of implementation of the programming as well as the outcomes for various populations of students.

An alternate approach for future research would be to conduct one or more case studies of Camp Invention ® programming processes and outcomes, using either a qualitative or mixed methods design. This type of design may not necessarily involve a large number of students, but may be able to provide in-depth insights into the lived experiences of diverse students as they participate in the program. Such studies may be helpful in building a theory of action and understanding how the various factors associated with students' intersectional backgrounds and identities manifest themselves in the course of the camp. A variation of this approach might be to add a longitudinal component, where students are followed over time after participating in a Camp Invention® program. Whether included in the context of an RCT or a case study design, a longitudinal research component could help to reveal the ways in which participation influences or is associated with high school and postsecondary choices and outcomes.

Several teachers offered potentially helpful suggestions for making Camp Invention's programming more culturally responsive. Their suggestions may serve as a beginning point for more targeted research about culturally responsive strategies for invention education programming. Some teachers' suggestions considered relevance of the material to the students' environments, commented that role model inventors could come from similar backgrounds as students, and were considerate for home-life needs are all in line with the definition of culturally responsive teaching as defined by Gay (2013). These suggestions are of great value when placed in the context of what a culturally responsive invention education lesson or activity could look like. Looking towards specific environmental or cultural issues in one's community that students may have heard about as opportunities for problem-solving, such as issues with tidal flooding in coastal communities, issues with lead pipes in communities with aged water systems, or even public transportation needs, would enhance the cultural relevance of the programming depending on where it takes place. Furthermore, building small collaborative groups that foster student confidence with peers and educators from similar backgrounds would also be in line with promoting culturally responsive teaching. Future research might examine how these resources can be developed, as well as their effectiveness in varying locations or with varying populations of students.

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