University of North Texas

Evaluation Team: Dr. Gerald Knezek, Dr. Rhonda Christensen, and Dr. Tandra-Tyler-Wood

C-STEM Student Report[1]

Overview

The Communication, Science, Technology, Engineering and Mathematics (C-STEM) Challenge competition occurred on April 25-26, 2014 in Houston, Texas. A team of external evaluators gathered online data from participating teachers and students regarding the challenge day activities. This report contains a summary of the findings based on analysis of data gathered from 238 C-STEM students while they were in attendance at the C-STEM Challenge. Most data were gathered toward the end of the competition, while the competition itself was toward the end of the school year. As a result, findings can be considered post treatment snapshot results that can be used to compare with findings from other STEM initiatives. These data can also serve as post treatment "baseline" data from which comparisons can be made for pre-post studies of C-STEM initiatives in the future.

About C-STEM

The C-STEM Challenge is a competition that engages students in multi-age groups to collaboratively solve six challenges that are designed by industry professionals and national standards-aligned project-based learning activities. Prior to participation, teachers receive training on implementing the C-STEM Challenge. Data gathered during the C-STEM Challenge should demonstrate the impact of teacher training on student learning and student performance in a STEM competition environment. The six challenges revolve around competitions in the creation and development of remotely controlled robots, geoscience, creative writing, sculpture, film, and photography. The students are required to participate in all challenge categories, providing students with an integrated STEM learning experience. The teachers are required to participate in 24 hours of professional development. C-STEM has a proven track record of success and a model that is scalable and sustainable. The organization has been researching how students and teachers want to experience STEM for more than ten years. The program kicks-off each fall and culminates in the spring with a competition.

Instrumentation: Indicators of STEM Career Interest

Two self-report surveys were used to gather data from C-STEM student participants. The STEM Semantic Survey and the Career Interest Questionnaire (CIQ) were used to evaluate student perceptions of STEM-related indices. The STEM Semantic Survey was also given to teacher participants in the program.

---

[1] By Rhonda Christensen, Gerald Knezek and Tandra Tyler-Wood

STEM Semantic Survey

The STEM Semantics Survey (Tyler-Wood, Knezek, & Christensen, 2010) was used to measure interest in each STEM subject as well as interest in STEM careers more generally. The STEM Semantics Survey was adapted from Knezek and Christensen's (1998) Teacher's Attitudes Toward Information Technology Questionnaire (TAT) derived from earlier Semantic Differential research by Zaichkowsky (1985). The five most consistent adjective pairs of the ten used on the TAT were incorporated as descriptors for target statements reflecting perceptions of science, mathematics, engineering and technology. A fifth scale representing interest in a career in science, technology, engineering, or mathematics was also created. As shown in Table 1, the internal consistency ratings for the five subscales from this data set ranged from 0.82 to 0.84, which can be considered very good (DeVellis, 1991). The five scales had five items each and each item was presented as semantic adjective pairs (exciting: unexciting; fascinating: ordinary; and so forth) to describe STEM dispositions and career attitudes.

Table 1. Internal Consistency Reliabilities for C-STEM Student Data on STEM Semantic Subscales

Subscale	**Cronbach's Alpha**	**No. of Items**
STEM Science	.82	5
STEM Mathematics	.84	5
STEM Engineering	.84	5
STEM Technology	.83	5
STEM Career	.83	5

Career Interest Questionnaire

The Career Interest Questionnaire is a Likert-type (1 = strongly disagree to 5 = strongly agree) instrument composed of 13 items on three scales. The three scales measure the following constructs: perception of supportive environments for pursuing a career in science, interest in pursuing educational opportunities that would lead to a career in science, and perceived importance of a career in science. The instrument was adapted from a longer instrument developed for a Native Hawaiian Studies project promoting STEM interest (focusing on science) in Hawaii. Adaptations of the instrument were based on a comprehensive analysis completed by Bowdich (2009). Reliabilities for data gathered on the CIQ subscales from C-STEM student participants ranged from .77 to 90 (shown in Table 2).

Table 2. Internal Consistency Reliabilities for C-STEM Student Data on CIQ Subscales

Subscale	**Cronbach's Alpha**	**No. of Items**
CIQ Part 1	.80	4
CIQ Part 2	.90	5
CIQ Part 3	.77	4
CIQ Total Survey	.93	13

Additional items were added to the battery of surveys to specifically evaluate the C-STEM program. These items included frequency of participation, likert-type questions and an open-ended question regarding the C-STEM program. These items are included in this analysis and report.

Student Participants

Two hundred thirty-eight (238) students ages 9 – 19 completed the STEM semantic and CIQ surveys along with additional items asked by the C-STEM team. Of the 238 students completing data, 46.6% (111) were male and 53.4% (127) were female. The frequencies and percentages for the age categories are listed in Table 3. Students also were asked to include their grade levels. Those frequencies and percentages are listed in Table 4. There was a broad range of student ages and grades represented at the competition. Table 5 includes the frequency of students representing participating schools.

Table 3. C-STEM Respondents by Age

Age	Frequency	Percent
9 or younger	37	15.5
10	27	11.3
11	31	13.0
12	22	9.2
13	31	13.0
14	26	10.9
15	18	7.6
16	19	8.0
17	15	6.3
18	6	2.5
19 or older	4	1.7
Total	236	99.2
Missing	2	.8
	238	100.0

Table 4. C-STEM Respondents by Grade Level

Grade Level	Frequency	Percent
3rd or below	27	11.3
4	29	12.2
5	28	11.8
6	32	13.4
7	19	8.0
8	30	12.6
9	30	12.6
10	12	5.0
11	8	3.4

12	14	5.9
Total	229	96.2
Missing	9	3.8
Total	238	100.0

Table 5. C-STEM Responses by School

School	Frequency	Percent
Bladensburg HS	6	2.5
Sam Houston HS	3	1.3
Energy Institute HS	22	9.2
Westside HS	11	4.6
John McDonogh HS	2	.8
North Houston Early College	4	1.7
William Wirt MS	9	3.8
Jackson MS	29	12.2
Texas Serenity Academy MS	10	4.2
Walipp TSU Preparatory Academy MS	10	4.2
Santa Fe MS	1	.4
Roger Heights Elem	9	3.8
Betsy Ross Elem	22	9.2
Petersen Elem	27	11.3
Kubacak Elem	5	2.1
Yellowstone Academy Elem	12	5.0
Tekoa Academy Elem	36	15.1
Total	218	91.6
Missing	20	8.4
Total	238	100.0

Findings Regarding STEM Dispositions

Findings regarding student dispositions toward STEM areas are reported in this section. Included are the mean scores for each of the measured subscales as well as comparisons by grade level and gender. As shown in Table 6, regarding the STEM Semantic measures, C-STEM students have a high interest in STEM as a career. The group mean rating for this area was 5.82, more positive than the semantic perceptions of science, technology, engineering, or mathematics for the same students, and more positive than the 5.02 average rating for STEM as a career among the MSOSW middle school project participants providing data during the same month in 2014. The effect size for being in C-STEM versus MSOSW is ES = .57, which would be considered moderately large according to guidelines by Cohen (1988). C-STEM students have higher interest in STEM as a career when compared to MSOSW participants.

Table 6. STEM Disposition Descriptive Statistics for C-STEM Respondents

Measurement Indices	**N**	**Mean**	**Std. Deviation**
STEM Semantic Survey			
STEM Science	233	5.65	1.36
STEM Math	233	5.23	1.53
STEM Engineering	233	5.58	1.46
STEM Technology	233	5.79	1.36
STEM Career	233	5.82	1.31
Career Interest Questionnaire			
CIQ Part1	232	3.69	.91
CIQ Part2	232	3.75	.96
CIQ Part3	232	3.96	.82
CIQ All	232	3.80	.82

School coding was used to categorize C-STEM students by elementary, middle school or high school levels. An analysis of variance was used to compare across the three groups. As shown in Table 7, high school students were highest on the dispositions where there were significant ($p < .05$) differences, on dispositions toward technology as well as on part three of the CIQ which is related to choosing a career that makes a difference in the world. The additional years of exposure and / or maturity may have enhanced dispositions in the high school age group.

Table 7. STEM Dispositions Compared Between Elementary, Middle School and High School Students

		N	**Mean**	**Std. Deviation**	**Sig.**
STEM Science	Elem	101	5.62	1.30	
	MS	76	5.52	1.47	
	HS	49	5.89	1.31	
	Total	226	5.65	1.36	.340
STEM Math	Elem	101	5.19	1.45	
	MS	76	5.22	1.57	
	HS	49	5.27	1.67	
	Total	226	5.22	1.53	.950
STEM Engineering	Elem	101	5.65	1.42	
	MS	76	5.30	1.55	
	HS	49	5.90	1.30	

	Total	226	5.59	1.45	.064
STEM Technology	Elem	101	5.67	1.40	
	MS	76	5.68	1.31	
	HS	49	6.27	1.25	
	Total	226	5.80	1.36	.024
STEM Career	Elem	101	5.77	1.22	
	MS	76	5.75	1.38	
	HS	49	6.07	1.37	
	Total	226	5.83	1.31	.333
CIQ Part1	Elem	101	3.69	.87	
	MS	76	3.62	.88	
	HS	49	3.78	1.00	
	Total	226	3.69	.90	.617
CIQ Part2	Elem	101	3.72	.89	
	MS	76	3.72	.96	
	HS	49	3.85	1.10	
	Total	226	3.75	.96	.701
CIQ Part3	Elem	101	3.82	.88	
	MS	76	4.02	.74	
	HS	49	4.23	.73	
	Total	226	3.98	.81	.011
CIQ All	Elem	101	3.74	.81	
	MS	76	3.78	.77	
	HS	49	3.95	.86	
	Total	226	3.80	.81	.343

As shown in Table 8, there appear to be no significant differences by gender on any of the measured STEM disposition indices. At first glance this appears to be different from the findings for MSOSW students in which middle school girls generally began lower than boys but tended to “catch up” over the time period of project activities (Knezek, Christensen, Tyler-Wood & Periathiruvadi, 2013). However, since data were gathered post treatment, at the end of the C-STEM project year, it is possible that the girls began with dispositions lower than boys and there was no significant difference by the end of the school year. The planned follow-up pre-post studies to be conducted in subsequent years will be able to answer the question of whether C-STEM students begin the program with few gender differences in attitudes toward STEM, or whether gender differences are ameliorated during the program year.

Table 8. Oneway Analysis of Variance for STEM Dispositions by Gender

		N	Mean	Std. Deviation	Sig
STEM Science	Male	110	5.68	1.36	
	Female	123	5.63	1.37	
	Total	233	5.65	1.36	.800
STEM Mathematics	Male	110	5.25	1.55	
	Female	123	5.20	1.51	
	Total	233	5.23	1.53	.786
STEM Engineering	Male	110	5.70	1.39	
	Female	123	5.48	1.52	
	Total	233	5.58	1.46	.259
STEM Technology	Male	110	5.94	1.38	
	Female	123	5.67	1.33	
	Total	233	5.79	1.36	.128
STEM Career	Male	110	5.81	1.31	
	Female	123	5.82	1.32	
	Total	233	5.82	1.31	.954
CIQ Part1	Male	109	3.74	.94	
	Female	123	3.64	.87	
	Total	232	3.69	.91	.432
CIQ Part2	Male	109	3.84	1.02	
	Female	123	3.67	.91	
	Total	232	3.75	.96	.174
CIQ Part3	Male	109	3.99	.85	
	Female	123	3.94	.80	
	Total	232	3.96	.82	.645
CIQ All	Male	109	3.85	.84	
	Female	123	3.74	.79	
	Total	232	3.80	.81	.303

C-STEM Sole Competition Experience

Students were asked if this C-STEM event was the only opportunity they have to compete in the STEM area. The large majority of students (69%) answered “yes”. If they said, “no”, they were higher ($p < .05$) in semantic perception of science and on the CIQ Part 1, having a supportive environment (home and community) for pursuing a career in science. These and additional results of the analysis of variance tests are listed in Table 9. Students having C-STEM as their only STEM competition opportunity are lower in all areas measured regarding STEM and STEM careers. These findings strongly emphasize the importance of the C-STEM program in providing for the students who may have no other opportunity to participate in STEM activities. C-STEM offers a valuable opportunity for development among these individuals.

Table 9. ANOVA for STEM Dispositions by "C-STEM provides me with the only STEM competition experience?"

		N	Mean	Std. Deviation	Sig
STEM Science	No	58	6.06	1.22	
	Yes	164	5.51	1.38	
	Total	222	5.66	1.36	.008
STEM Mathematics	No	58	5.32	1.65	
	Yes	164	5.18	1.48	
	Total	222	5.21	1.52	.547
STEM Engineering	No	58	5.73	1.46	
	Yes	164	5.55	1.45	
	Total	222	5.60	1.45	.434
STEM Tech	No	58	5.96	1.28	
	Yes	164	5.77	1.36	
	Total	222	5.82	1.34	.375
STEM Career	No	58	5.96	1.18	
	Yes	164	5.80	1.33	
	Total	222	5.84	1.30	.441
CIQ Part1	No	58	3.88	.86	
	Yes	164	3.62	.91	
	Total	222	3.69	.90	.052
CIQ Part2	No	58	3.91	1.01	
	Yes	164	3.70	.93	
	Total	222	3.75	.96	.146
CIQ Part3	No	58	4.13	.75	
	Yes	164	3.92	.82	
	Total	222	3.97	.80	.077
CIQ All	No	58	3.97	.81	
	Yes	164	3.74	.79	
	Total	222	3.80	.80	.060

Interest in Participation in C-STEM

As shown in Table 10, 69% of the student respondents attending the C-STEM challenge event in 2014 were there for the first time, while 87% of the students had attended 1-3 years. However, some students (n = 7) had attended as many as 10 years. For students of this age range, attendance for 10 years may represent half their lifetimes and is a clear indication of long-term interest.

Table 10. Frequency Distribution of Responses to “How many CSTEM challenge competitions have you participated in?”

Years of Participation	Frequency	Percent
1 year	165	69.3
2 years	32	13.4
3 years	11	4.6
4 years	6	2.5
5 years	1	.4
6 years	2	.8
7 years	3	1.3
8 years	1	.4
9 years	1	.4
10 years	7	2.9
Total	229	96.2
Missing	9	3.8
	238	100.0

As shown in Table 11, 192 of the 232 respondents (83%) agreed (n = 57) or strongly agreed (n = 135) that they would like to participate in the C-STEM program next year. Only 14 of the 232 respondents (6%) disagreed or strongly disagreed they would like to participate next year. This is a highly positive expression of ongoing interest with well over half the students (135/232 = 58%) strongly in agreement they would like to participate in the C-STEM program again next year.

Table 11. Frequency Distribution of Responses to “I would like to participate in the C-STEM program next year?”

	Frequency	**Percent**
Strongly Disagree	6	2.5
Disagree	8	3.4
Undecided	26	10.9
Agree	57	23.9
Strongly Agree	135	56.7
Total	232	97.5
System Missing	6	2.5
Total	238	100.0

Additional evidence of high interest and perceived value among students for C-STEM participation can be identified. As shown in Table 12, the group mean level of agreement that “CSTEM develops confidence in math and science” was 4.03 on a scale of 1 = strongly disagree to 5 = strongly agree. This finding indicates the collective perception of the student group lies between “agree” and “strongly agree” for this item. For the item “I would like for C-STEM to be a class at my school” the group mean perception is even higher at 4.05, and for “I would like to participate in the C-STEM program next year” the group mean perception is highest among the three, at 4.32. Although all three ratings are high, the group mean rating for “I would like to participate in the C-STEM program next year” is significantly ($t = 2.78$, $p < .01$) higher than for the next highest item. Student participants feel strongly that they would like to participate in C-STEM again next year.

Table 12. Likert Ratings of C-STEM by Students

	N	Mean	Std. Deviation
CSTEM develops confidence in math and science	232	4.03	1.114
I would like for C-STEM to be a class at my school.	232	4.05	1.026
I would like to participate in the C-STEM program next year.	232	4.32	.982

Type of C-STEM Activities

As shown in Table 13, the greatest number of student respondents reported they were members of the Robotics Team (21%), followed by the Mural Team (15%), the Geoscience Team (14%), the Sculpture Team (13%), and the Photography Team (12%) tied with the Film Making Team (12%). These activities are very evenly represented, with the exception of participation notably largest in Robotics.

Table 13. Type of C-STEM Activity: Distribution by Student Activity Team

Activity Team	Frequency	Percent
Robotics Team	49	20.6
Photography Team	28	11.8
Mural Team	36	15.1
Sculpture Team	30	12.6
Film Making Team	28	11.8
Geoscience Team	33	13.9
Other	26	10.9
Total	230	96.6
Missing	8	3.4
Total	238	100.0

As shown in Table 14, no significant ($p < .05$) differences in STEM dispositions for C-STEM were found to be attributable to team membership. This should probably be considered a positive finding, in that the overall highly positive STEM dispositions found for C-STEM participants do not appear to be isolated to one type of activity.

Table 14. ANOVA for STEM Dispositions by Team Participation

		N	Mean	Std. Deviation	Sig.
STEM Science	Robotics team	9	5.47	1.38	
	Photography team	10	5.10	1.47	

	Mural team	11	5.95	1.34	
	Sculpture team	13	5.58	1.29	
	Film making team	9	5.62	1.47	
	Geoscience team	11	5.45	1.42	
	Other	14	6.10	1.36	
	Total	77	5.64	1.37	.682
STEM Math	Robotics team	9	6.24	1.12	
	Photography team	10	5.24	1.89	
	Mural team	11	4.62	1.62	
	Sculpture team	13	4.89	1.08	
	Film making team	9	5.89	1.33	
	Geoscience team	11	4.87	1.70	
	Other	14	5.46	1.86	
	Total	77	5.27	1.58	.218
STEM Engineering	Robotics team	9	6.16	1.12	
	Photography team	10	5.28	1.31	
	Mural team	11	5.18	2.00	
	Sculpture team	13	5.49	1.18	
	Film making team	9	5.55	1.46	
	Geoscience team	11	5.44	1.64	
	Other	14	5.46	1.38	
	Total	77	5.49	1.44	.857
STEM Technology	Robotics team	9	6.16	1.06	
	Photography team	10	5.52	1.38	
	Mural team	11	5.91	1.54	
	Sculpture team	13	5.43	1.15	
	Film making team	9	5.47	1.39	
	Geoscience team	11	5.42	1.50	
	Other	14	6.09	1.24	
	Total	77	5.72	1.31	.680
STEM Career	Robotics team	9	5.93	1.18	
	Photography team	10	5.24	1.18	
	Mural team	11	5.98	1.09	
	Sculpture team	13	5.55	1.31	
	Film making team	9	6.09	1.20	
	Geoscience team	11	6.36	1.09	
	Other	14	5.87	1.09	
	Total	77	5.85	1.17	.402
CIQ Part1	Robotics team	9	3.78	.76	
	Photography team	10	3.43	.92	
	Mural team	11	3.77	.96	
	Sculpture team	13	3.42	.53	
	Film making team	9	3.86	.73	
	Geoscience team	11	3.93	.70	
	Other	14	3.77	.86	

	Total	77	3.70	.78	.622
CIQ Part2	Robotics team	9	3.87	1.10	
	Photography team	10	3.48	.92	
	Mural team	11	3.96	.95	
	Sculpture team	13	3.57	.62	
	Film making team	9	3.87	.96	
	Geoscience team	11	3.73	1.23	
	Other	14	3.80	1.03	
	Total	77	3.75	.95	.916
CIQ Part3	Robotics team	9	3.94	1.05	
	Photography team	10	4.08	.64	
	Mural team	11	3.93	.78	
	Sculpture team	13	3.69	.58	
	Film making team	9	4.28	.70	
	Geoscience team	11	4.36	.69	
	Other	14	3.98	.62	
	Total	77	4.02	.72	.361
CIQ All	Robotics team	9	3.86	.89	
	Photography team	10	3.65	.72	
	Mural team	11	3.90	.87	
	Sculpture team	13	3.56	.52	
	Film making team	9	3.99	.74	
	Geoscience team	11	3.99	.78	
	Other	14	3.85	.79	
	Total	77	3.82	.74	.785

Career Aspirations by C-STEM Participants

Students were asked to select a career that they planned to have in the future. As shown in Table 15, C-STEM participants have the strongest interest in a career in engineering, with 29% selecting this category. The research team judges this to be a unique feature of the C-STEM program, since six years of previously-gathered data across five US states had indicated that engineering is the least understood and least selected career among elementary and middle school aged children in general. When separating students out by middle school and high school, it is of note that even a larger percentage of high school students plan to have a career in engineering (36%) than the group as a whole. Both middle school and high school groups are shown in Tables 16 and 17. Note that 27% of the students responding to the C-STEM survey plan to have a career outside of STEM (selected “Other”). This finding can be considered a positive attribute of the C-STEM program as well, in that it attracts students interested in STEM but planning to have their main career in another field. It appears that C-STEM participants are not all uniform in their life goals but still have common ground in their interest in C-STEM activities.

Table 15. C-STEM Student Participant Plans for Future Careers

Career Area	Frequency	Percent
Science	43	18.1
Technology	27	11.3
Engineering	69	29.0
Mathematics	29	12.2
Other	64	26.9
Total	232	97.5
System Missing	6	2.5
Total	238	100.0

Table 16. Middle School Student Plans for Future Careers

Career Area	Frequency	Percent
Science	12	14.8
Technology	8	9.9
Engineering	21	25.9
Mathematics	12	14.8
Other	26	32.1
Total	79	97.5
Missing	2	2.5
Total	81	100.0

Table 17. High School Student Plans for Future Careers

Career Area	Frequency	Percent
Science	10	15.6
Technology	10	15.6
Engineering	23	35.9
Mathematics	4	6.3
Other	17	26.6
Total	64	100.0

Open-Ended Responses

One hundred, eighty-six students out of a possible 244 responded to the question, “Next year, I wish C-STEM would offer students the opportunity to…” For the most part, the responses fell into the nine categories listed in Table 18 with examples of the responses received. Most of the responses appear to address food, time for socializing and having fun. However some addressed desires to “build more race cars” and “allow more students in robotics.”

Table 18. Categories of Responses to Open Ended Question: “Next year, I wish C-STEM would offer students the opportunity to…”

1. Facility/food - 24 responses classified in this category

   Examples:
   More time to work on things.
   More food.
2. Robotics - 20 responses classified in this category
   Examples
   More time in robotics.
   Let me in robotics.
3. More activities/time - 7 responses classified in this category
   Examples
   More involving activities
   More energy sciences.
4. Race cars - 5 responses classified in this category
   Examples
   Build and make race cars.
   Race cars
5. Field trips - 5 responses classified in this category
   Examples
   Everything and more field trips
   Field trips
6. Scholarships/Funding for outside Learning Opportunities - 4 responses classified in this category
   Examples
   Have scholarships for students who want to attend college in the future.
   Have the opportunity to get a scholar ship or any type of help for the future.
7. Rewards or participation/medals - 7 responses classified in this category

   Examples
   Give stuff for free
   Give ribbons for third place winners
8. Have a good time - 4 responses classified in this category
   Examples
   Have fun again.
   Party
9. Career - 4 responses classified in this category
   Examples
   Have a good career.
   Make a poem based on a stem career.

Conclusions

The C-STEM program clearly nurtures positive STEM dispositions in students. At least one dozen indicators all point to this conclusion. Also apparent is that the C-STEM challenge event in particular is enjoyable to practically every student who attends, to a point where a very large percentage say they want to return the following year. Non-trivial numbers of participants have in fact returned year after year, up to 10 years for some. Perhaps the most unique aspect of the C-STEM program is the large number of students who report they wish to have a career in engineering. The percentage (29%) is far higher than any number encountered by the research team from comparable aged students over the past six years. Yet to be determined is whether these students begin the C-STEM program with lower STEM aspirations and dispositions that are enhanced over time, or if the students choose C-STEM because of their interests, and the program keeps their interests and aspirations from dying. Future research is planned for this area. However, regardless of the answer to this question, the C-STEM program should be viewed as a positive contribution to the prospective STEM workforce of the US in the future. Fully 69% of the 2014 participants reported C-STEM as their only STEM competition opportunity. These students would likely have no other opportunity at this critical stage in their lives for such a positive experience with STEM.

References

Bowdich, S. (2009). *Analysis of Research Exploring Culturally Responsive Curricula in Hawaii.* Paper presented to the Hawaii Educational Research Association Annual Conference, February 7, 2009.

DeVellis, R.F. (1991). *Scale development*. Newbury Park, NJ: Sage Publications.

Knezek, G., & Christensen, R. (1998, March). *Internal consistency reliability for the teachers' attitudes toward information technology (TAT) questionnaire*. In S. McNeil, J. Price, S. Boger-Mehall, B. Robin, & J. Willis (Eds.), *Proceedings of the Society for Information Technology in Teacher Education Annual Conference* (pp. 831-836). Bethesda, MD: Society for Information Technology in Teacher Education.

Knezek, G., Christensen, R., Tyler-Wood, T., & Periathiruvadi, S. (2013). Impact of environmental power monitoring activities on middle school student perceptions of STEM. *Science Education International, 21* (1), 98-123.

Tyler-Wood, T., Knezek, G., & Christensen, R. (2010). Instruments for assessing interest in stem content and careers. *Journal of Technology and Teacher Education, 18*(2), 341-363.

Zaichkowsky, J. L. (1985). Measuring the involvement construct. *Journal of Consumer Research, 12*(3), 341-352.

University of North Texas

Evaluation Team: Dr. Gerald Knezek, Dr. Rhonda Christensen, and Dr. Tandra-Tyler-Wood

C-STEM Teacher Report 2014[2]

Introduction

Thirty-three teachers completed data following the C-STEM competition that took place in April at the George Brown Convention Center in Houston in which the teachers attended the competition with their students. This report includes descriptive and summative information regarding the data provided by the participating teachers related to STEM dispositions, STEM instructional dispositions and technology integration dispositions. The largest percentage of teachers in this sample consisted of females (75.8%, n=25) with only 8 (24.2%) males contributing data. The average age of the teachers is 38 with a range of 24 to 62 years. Teachers reported an average of 11 years of teaching experience with a range from 0 to 32 years. The large majority of the teachers (n = 22, 66.6%) indicated teaching at either the middle school (n=11) or high school level (n=11) (Table 1). As shown in Table 2, 46% of the teachers had earned a graduate degree. Table 3 shows that these teachers were well distributed across the subjects of science, language arts, and technology with a high percentage (33%) indicating a teaching assignment in a subject not listed.

Table 1. Frequency Distribution for Grade Level in Which Respondents Teach

	Frequency	Percent
Pre-K - Grade 2	3	9.1
Grades 3-5	5	15.2
Grades 6-8	11	33.3
High School	11	33.3
Administration	1	3.0
Don’t teach	2	6.1
Total	33	100.0

Table 2. What is the highest degree you have received?

	Frequency	Percent
High School	1	3.0
BA/BS	16	48.5
MA/MS	13	39.4
EdD/PhD	2	6.1
Other	1	3.0
Total	33	100.0

[2] By Rhonda Christensen, Gerald Knezek and Tandra Tyler-Wood

Table 3. What subject do you teach?

	Frequency	Percent
Science	8	24.2
Mathematics	2	6.1
Social Studies	0	0
Language Arts	7	21.2
Technology	5	15.2
Other	11	33.3
Total	33	100.0

Use of Technology

As shown in Table 4, 49% of these teachers use a computing device in their home 16 or more hours per week. Table 5 indicates 42% use a computing device ***daily*** for learning activities in their classrooms.

Table 4. How many hours per week do you currently use a computing device at home (including WWW access)?

		Frequency	Percent
	0 hours	0	0
	1 hour	2	6.1
	2-3 hours	1	3.0
	4-7 hours	8	24.2
	8-15 hours	6	18.2
	16-31 hours	7	21.2
	More than 31 hours	9	27.3
	Total	33	100.0

Table 5. How frequently do your students use computing devices for learning activities in school?

		Frequency	Percent
	Never	0	0
	Occasionally	6	18.2
	Weekly	13	39.4
	Daily	14	42.4
	Total	33	100.0

Instrumentation

Data from the STEM Semantic Survey, Stages of Adoption of Technology, C-STEM Instructional items and demographic items were gathered from teachers who attended the C-STEM competition with their students.

The STEM Semantics Survey was adapted from Knezek and Christensen's (1998) Teacher's Attitudes Toward Information Technology Questionnaire (TAT) derived from earlier Semantic Differential research by Zaichkowsky (1985). The five most consistent adjective pairs of the ten used on the TAT were incorporated as descriptors for target statements reflecting perceptions of Science, Math, Engineering and Technology. A fifth scale representing interest in a career in Science, Technology, Engineering, or Math (STEM) was also created. Internal consistency reliabilities for the five scales of the STEM Semantics Survey typically range from Alpha = .90 to Alpha = .94 for students such as those participating in this study (Tyler-Wood, Knezek & Christensen, 2010). These reliability estimates fall in the range of "excellent" according to guidelines provided by DeVellis (1991). The five scales had five items each and each item was presented as semantic adjective pairs (fascinating: mundane; exciting: unexciting; and so forth) to describe STEM dispositions and career attitudes.

Stages of Adoption (Christensen, 1997) is a self-assessment of a teacher's level of adoption of technology, based on earlier work by Russell (1995). There are six possible stages in which educators rate themselves: Stage 1 - Awareness, Stage 2 - Learning the process, Stage 3 - Understanding and application of the process, Stage 4 - Familiarity and confidence, Stage 5 - Adaptation to other contexts, and Stage 6 - Creative application to new contexts.

C-STEM Instructional items were created in collaboration between the project personnel and the evaluation team. The items were rated on a likert-type scale of 1 to 5 with 1 = Strongly Disagree and 5 = Strongly Agree. Reliabilities were calculated for the five items as a scale and Cronbach's alpha was .90 for this group of teachers.

Dispositions of C-STEM Teachers in Context

As shown in Table 6 and graphically displayed in Figure 1, C-STEM teacher dispositions across all rating categories reported on the STEM Semantic Survey, were comparable to those of teachers participating in the Middle Schoolers Out to Save the World (MSOSW) project funded by the National Science Foundation, and teachers in the state of Hawaii STEM Academy Professional Development Program. When compared with the MSOSW project teachers representing five states, C-STEM teachers were higher in dispositions toward engineering and dispositions toward technology. Effect sizes for dispositions towards engineering and technology were Cohen's d = +.44 which would be considered moderate in magnitude (Cohen, 1988) and educationally meaningful (Bialo & Sivin-Kachala, 1996). C-STEM teachers were lower compared to MSOSW teachers in semantic perceptions of STEM as a Career (ES = -.44). The average magnitude of the difference between C-STEM teachers and MSOSW teachers across the five disposition measures was Cohen's d = +.04, which is very close to zero.

When compared with middle school teachers participating in the state of Hawaii STEM Academy Professional Development Program, C-STEM teachers were almost identical in their STEM disposition profiles. Effect sizes ranged from -.21 (small) to +.10 (very small). The average magnitude of the difference between C-STEM teachers and Hawaii STEM Academy teachers, across the five disposition measures, was Cohen's d = -.02, which is very close to zero.

Table 6. Comparison of Means for STEM Semantic Scales for Three Groups of Teachers Involved in STEM Activities

	C-STEM teachers			MSOSW Teachers Fall 2013			Hawaii Teachers		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
STEM Science	33	6.41	.89	14	6.67	.57	48	6.58	.72
STEM Math	33	5.42	1.43	14	5.26	1.10	48	5.40	1.33
STEM Engineering	33	6.25	1.00	14	5.81	1.01	48	6.14	1.13
STEM Technology	32	6.51	.80	14	6.13	.93	48	6.44	.93
STEM Career	33	6.32	1.09	14	6.67	.49	48	6.41	.96

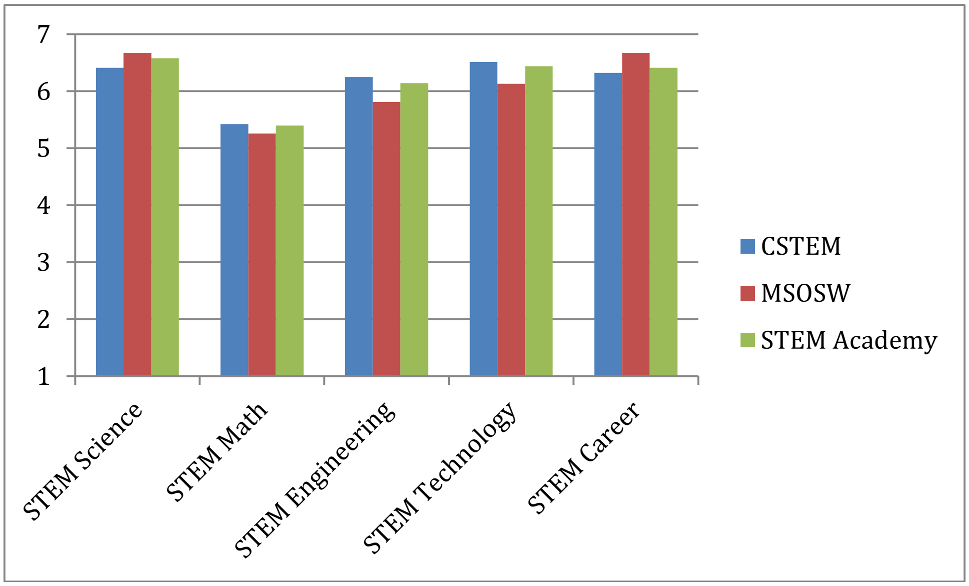

Figure 1. Comparison of C-STEM teacher dispositions to MSOSW project teachers and Hawaii STEM Academy teachers.

C-STEM Instructional Practices

Five items were added by the project personnel and evaluators regarding STEM instructional practices. As a scale, the C-STEM Instruction mean was 4.42 (SD=.79, n=33) on a scale of 1 = strongly disagree to 5 = strongly agree. This represents high agreement among the teachers in favor of C-STEM instructional practices. Means for individual items are shown in Table 7. While all five items were positively rated, the highest rated item was having the students participate in the program the next year. Frequencies for each of the items are shown below in Tables 8 – 12.

Table 7. Descriptive Statistics for C-STEM Instructional Practices Items

Survey Items	Mean	Std. Dev	N
1. I am confident integrating STEM into other subjects.	4.41	1.012	32
2. I am comfortable teaching STEM content to my students.	4.47	.842	32
3. I effectively integrate C-STEM strategies into my classroom.	4.28	.958	32
4. I encourage students to develop innovative STEM-related projects.	4.25	1.047	32
5. I would like for my students to participate in the C-STEM program next year.	4.59	.837	32

Table 8. I am confident integrating STEM into other subjects.

	Frequency	Percent
Strongly Disagree	2	6.1
Disagree	0	0
Undecided	0	0
Agree	11	33.3
Strongly Agree	20	60.6
Total	33	100.0

Table 9. I am comfortable teaching STEM content to my students.

	Frequency	Percent
Strongly Disagree	1	3.0
Disagree	0	0
Undecided	1	3.0
Agree	11	33.3
Strongly Agree	20	60.6
Total	33	100.0

Table 10. I effectively integrate CSTEM strategies into my classroom.

	Frequency	Percent
Strongly Disagree	1	3.0
Disagree	0	0
Undecided	5	15.2
Agree	9	27.3
Strongly Agree	18	54.5
Total	33	100.0

Table 11. I encourage students to develop innovative STEM-related projects.

	Frequency	Percent
Strongly Disagree	1	3.0
Disagree	2	6.1
Undecided	2	6.1
Agree	10	30.3
Strongly Agree	17	51.5
Total	32	97.0
System Missing	1	3.0
Total	33	100.0

Table 12. I would like for my students to participate in the CSTEM program next year.

	Frequency	Percent
Strongly Disagree	1	3.0
Disagree	0	0
Undecided	1	3.0
Agree	7	21.2
Strongly Agree	24	72.7
Total	33	100.0

Technology Integration

Teachers completed the one-item Stages of Adoption of Technology survey that ranges from 1 to 6. Descriptions of each stage are shown in Table 13. The mean stage for the C-STEM teachers is 5.59 (n=32, SD = .95), lying between adaptation of technology to other contexts (Stage 5) and creative application to new contexts (Stage 6). By way of comparison, the group mean value of teachers (n = 1642) in a large North Texas school district that had bond elections providing 10 years of systematic technology integration training was 5.20, in 2011. We can therefore assume that the level of technology integration for C-STEM teachers is high. The magnitude of the difference between C-STEM teachers and those in the technology-intensive North Texas school district is approximately ES = (5.59-5.20)/.95 = .41, which would be considered educationally meaningful according to published standards (Bialo & Sivin-Kachala, 1996).

Table 13. Distribution of Stages of Adoption of Technology for C-STEM Teachers, Spring 2014

Stage	Freq.	Percent
Stage 1: Awareness I am aware that technology exists but have not used it - perhaps I'm even avoiding it. I am anxious about the prospect of using computers.	0	0
Stage 2: Learning the process I am currently trying to learn the basics. I am sometimes frustrated using computers. I lack confidence when using computers.	0	0
Stage 3: Understanding and application of the process I am beginning to understand the process of using technology and can think of specific tasks in which it might be useful.	3	9.1
Stage 4: Familiarity and confidence I am gaining a sense of confidence in using the computer for specific tasks. I am starting to feel comfortable using the computer.	1	3.0
Stage 5: Adaptation to other contexts I think about the computer as a tool to help me and am no longer concerned about it as technology. I can use it in many applications and as an instructional aid.	2	6.1
Stage 6: Creative application to new contexts I can apply what I know about technology in the classroom. I am able to use it as an instructional tool and integrate it into the curriculum.	26	78.8
Total	32	97.0
System Missing	1	3.0
Total	33	100.0

As shown in Table 14, no significant ($p < .05$) differences were found in the level of STEM dispositions based on C-STEM teacher Stages of Adoption of Technology. However, note that the lowest reported Stage of Adoption was Stage 3, which indicates all C-STEM teachers responding were middle to upper stage teachers. Perhaps if some of the teachers had been Stage 1 or Stage 2 regarding technology integration, significant ($p < .05$) STEM disposition differences may have emerged. Apparently the C-STEM program does not attract low technology integrating teachers.

Table 14. One-way Analysis for STEM Dispositions by Stages of Adoption of Technology

		N	Mean	Std. Deviation	Sig.
STEM Science	3	3	6.5333	.23094	
	4	1	6.2000	.	
	5	2	6.9000	.14142	
	6	26	6.3423	.98557	
	Total	32	6.3906	.89959	.854
STEM Math	3	3	5.5000	1.29904	
	4	1	7.0000	.	
	5	2	5.7000	1.83848	
	6	26	5.2692	1.45541	
	Total	32	5.3719	1.42444	.686
STEM Engineering	3	3	6.0667	.23094	
	4	1	7.0000	.	
	5	2	6.7000	.42426	
	6	26	6.1769	1.09738	
	Total	32	6.2250	1.00931	.779
STEM Technology	3	3	6.6000	.34641	
	4	1	7.0000	.	
	5	2	6.9000	.14142	
	6	25	6.4240	.87430	
	Total	31	6.4903	.80306	.783
STEM Career	3	3	6.2667	.11547	
	4	1	7.0000	.	
	5	2	6.7000	.42426	
	6	26	6.2462	1.21235	
	Total	32	6.3000	1.10483	.879

Suggestions for New Activities

An open-response question was asked regarding suggestions to improve the program in subsequent years. The teachers were asked what they wish C-STEM would offer students next year. Sixteen teachers added comments related to next year. The unedited comments are below.

C-STEM Teacher Comments

- more hands on and technical projects
- more choices on other projects
- second and third place recognition
- I think CSTEM is an excellent opportunity for students. It introduces them to things that can help them in the future.
- More artistic challenges in conjunction with others (ie - musical theater or performance art with creative writing)
- A more detailed writing component
- Their task on time.
- More clarity on what is expected of them from the challenge.
- Prizes for 2nd and 3rd Place
- Innovation and vivid project opportunities and maybe a chance to have a conference where students talk to one another and gain knowledge from their peers.
- I wish CSTEM would incorporate more technologies to the robotics competition with more freedom to construct mechanisms. Also allow robotics to print 3D pieces to be used on the robot.
- More math-related events
- We have great challenges this year let us refine these challenges without adding new ones
- Summer programs
- A clearer judging rubric that is equal to the requirements laid out in the teacher training. Instructions that are all in one place.
- ...a more user-friendly website.

Conclusion

Collective findings from analysis of C-STEM teacher data indicate that C-STEM teachers tend to be high in their STEM dispositions, comparable to teachers in the NSF-funded Middle Schoolers Out to Save the World (MSOSW) project, and almost identical to their peers in the state of Hawaii STEM Academy Professional Development Program. C-STEM teachers are very high in their weekly use of computing technologies at home, while 42% also make daily use of information technologies for classroom learning activities with their students. These data are corroborated by high self-reported Stages of Adoption of Technology by the C-STEM teachers. C-STEM teachers are also positive toward instructional practices promoted by the C-STEM program. Teachers would like to see prizes awarded to their students for second and third place finishers, and a wider selection of activities across the STEM disciplines.

References

Bialo, E.R. & Sivin-Kachala, J. (1996). The effectiveness of technology in schools. A summary of recent research. *School Library Media Quarterly 25*(1), 51-57.

Christensen, R. (1997). Effect of technology integration education on the attitudes of teachers and their students. Doctoral dissertation, University of North Texas. Available online: http://courseweb.tac.unt.edu/rhondac

Chen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Lawrence Earlbaum Associates.

DeVellis R. F. (1991). *Scale development.* Newbury Park, NJ: Sage Publications

Knezek, G., & Christensen, R. (1998, March). Internal consistency reliability for the teachers' attitudes toward information technology (TAT) questionnaire. In S. McNeil, J. Price, S. Boger-Mehall, B. Robin, & J. Willis (Eds.), *Proceedings of the Society for Information Technology in Teacher Education Annual Conference* (pp. 831-836). Bethesda, MD: Society for Information Technology in Teacher Education.

Russell, A. L. (1995). Stages in learning new technology: Naive adult email users. *Computers in Education, 25*(4), 173-178.

Tyler-Wood, T., Knezek, G., & Christensen, R. (2010). Instruments for assessing interest in stem content and careers. *Journal of Technology and Teacher Education, 18*(2), 341-363.

Zaichkowsky, J. L. (1985). Measuring the involvement construct. *Journal of Consumer Research, 12*(3), 341-352.