AC 2012-3220: NON-ACADEMIC INTERVENTIONS IN STEM TRAINING

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Non-Academic Interventions in STEM Training

Abstract

The proposed ITEST study is designed to implement and test the efficacy of an intervention developed as part of an NSF-funded project by the team of investigators at Longwood University and Virginia State University. This intervention develops the underlying thinking skills in students necessary for success in STEM courses and careers. Rather than relying only on classroom content and high-level thinking skills, this intervention also includes a classroom component involving an innovative video game programming curriculum developed by the investigators. The impact of this intervention will be assessed at a critical developmental period: the entry into high school (9^{th} grade). Over the three-year period of the project, the groups of participants have been assessed on a number of different variables to develop a model of how these variables impact the cognitive interventions. These variables have all been implicated in lowered academic performance, and the information provided by the model will allow the development of future non-academic interventions associated with these variables to enhance the impact of cognitive training.

Introduction

An Information Technology Experiences for Students and Teachers (ITEST) project sponsored by the National Science Foundation (NSF) at Longwood and Virginia State Universities addressed a unique pedagogy and teaching method in science, technology, engineering, and math (STEM) disciplines for middle school students in the Digispired project. The primary goal of project was to provide learning and research opportunities to middle school students by focusing on programming and thus gaming, and the four science themes through Saturday and summer programs for three years. Within this 36-month project, 90 low-income rural and urban students (1) learned about technologies involved in game products; (2) learned about programming, computer graphics, and animation; (3) created games on four science themes – recycling, nutrition, physical exercise or activity, and substance abuse; (4) finalized their interactive game projects for distribution in local educational communities; and (5) shared their learning experiences and products in educational conferences of students and of teachers of mathematics, science, and technology. The project staff developed professional development and instructional resources for replication and identified instructional models and strategies that are appealing to the interactive game generation. This paper discusses the results and ways in which the project related to the natural interests of young people in interactive games and thus motivated them to learn programming and explore technology and software engineering careers.

Generally, the *Digispired* project shows promise for increasing students' knowledge and skills with respect to technology both over time and in relation to their peers. Students also showed significantly more positive attitudes toward technology in several areas when compared to similar, non-participating peers. Participating students also reported that the program was more interesting and helpful than technology courses offered at their schools, and they expressed a desire to keep learning more about different kinds of software and programming. The primary challenges were noted in students' mixed perceptions of the Summer Academies.

Evaluation Findings

The following sections detail the findings of the Digispired evaluation during the 2008-2009 school year.

Summer Academy Implementation Quality

Participant feedback on the *Digispired* Summer Academies held in 2007, 2008, and 2009 was collected through the administration of the *Summer Academy Participant Feedback* survey, administered near the end of each summer's activities. Comparisons of all indicators are presented in separate tables for positive and negative indicators (Tables 1 and 2). This arrangement allows for comparisons by gender, by year, or by both attributes. Participants who did not report gender are not included in Tables 1 and 2.

Table 1. Positive Indicators of Summer Academy Implementation: Percentage of Participants Reporting "Most of the time" or "Always"

During the Summer Academy, how often did you feel . . .	2007		2008		2009	
	Female	Male	Female	Male	Female	Male
Challenged	40.0	23.7	39.1	27.2	66.7	54.9
Successful at what you were doing	75.0	68.4	65.2	63.6	66.7	67.7
Excited about what you were doing	70.0	71.0	52.2	60.0	55.6	67.8
Eager to learn more about the topic	60.0	63.2	52.2	48.5	38.9	61.3
That what you were learning was interesting	75.0	73.7	52.2	60.6	61.1	80.6
That what you were learning was important to your life now	70.0	60.5	39.1	51.5	38.9	42.0
That what you were learning was important for you in the future	70.0	73.7	73.9	69.7	66.7	71.0

Table 2. Negative Indicators of Summer Academy Implementation: Percentage of Participants Reporting "Most of the time" or "Always"

During the Summer Academy, how often did you feel . . .	2007		2008		2009	
	Female	Male	Female	Male	Female	Male
Bored	10.0	7.9	43.5	12.1	22.2	25.9
That what you were doing was too difficult	5.0	7.9	4.3	6.0	5.6	12.9
That what you were doing was too easy	30.0	15.8	8.7	6.1	0	9.7

Notable Findings from Summer Academy Implementation Data

- Participants reported being more "challenged" by the 2009 summer academy than any other year. Females were more likely than males to report being "challenged" across all three years.
- Males were more likely than females in 2009 to be of the opinion that what they learned in the summer academy is "important to their future."
- Males were more likely in 2009 than in any other year to report that they were interested in what they were learning.
- For males, six of the positive indicators increased from the 2008 to 2009 implementation (excluding "what you were learning was important to your life now"). For females, to other positive indicators decreased from the 2008 to 2009 implementation: "eager to learn more about the topic" and "what you were learning was important for you in the future."
- Additionally, several positive indicators showed decreases from the 2007 to 2009 implementation (excluding "how often did you feel challenged"). These findings indicate that the implementation quality, in general, increased between 2008 and 2009, particularly for male students. The findings could also indicate that the quality of the 2009 implementation was not to the standard of the quality of the 2007 implementation in some aspects.
- Male and female students reported feeling successful in what they were doing at roughly comparable levels in each of the three years.

- The most notable change among positive indicators of summer academy implementation quality is the rate at which female students report that what they are doing is "important to their life now"—with a decrease over the three years of more than 30% in the number reporting "most of the time" or "always."

- With regard to negative indicators, males indicated a steady increase in "how often did you feel bored," throughout the three years. Females, however, reported being less bored in 2009 than in 2008, but more bored in 2009 than in 2007.

- Both males and females perceived the 2009 summer academy to be more difficult than the previous two years. Throughout the three years, males perceived the summer academies to be more difficult than did the female participants. Interestingly, in 2009 more males than females reported that the summer academy was "too easy," most of the time or always. Females' perceptions of how easy the material was decreased steadily over the three years.

Participant Attitudes and Interests

The *Participant Attitudes and Interests Survey (PAI)* was administered late in the 2007 implementation year to Digispired participants at all three sites and to a comparison group of students of a similar age from the same school divisions. The PAI was again administered to participants in 2008 and to participants and comparison students in 2009. All administrations of the PAI instrument were web-based, with respondents completing the survey as groups in computer labs, supervised by *Digispired* or school staff members. In 2009, participants at one site did not complete the survey, resulting in a lower response rate than in previous years.

In 2007, the participant group was compared to the comparison students to determine whether the students selected for the *Digispired* program were similar to students who were not participating. This early comparison provided a helpful basis for future comparisons and helped clarify assertions about the selection and application process and the degree to which it might influence the make-up of the participant group. If, for example, the selection process recruited—by design or by accident—students who were disproportionally interested in STEM careers before participation, conclusions about the ability of the program to encourage students to pursue such opportunities might be reasonably questioned. Independent-samples *t* tests found no statistically significant differences between the groups' mean responses, indicating that even where differences between the *Digispired* participant group and the comparison group were evident, none were significant.[1] This suggests that *Digispired* students, as assessed in 2007, were "like their classmates," at least in terms of their attitudes and interests indicated by items on the PAI.

On the other hand, in 2009, *Digispired* participants and comparison students differed significantly on many PAI items. The significant differences are presented in Table 3. The comparison groups in 2007 and 2009 consisted of different individuals. The 2007 comparison students had more positive attitudes toward technology than the 2009 comparison students, which may help explain the participant-comparison differences in 2009.

Table 3. PAI Items/Categories Showing Significant Participant-Comparison Differences in 2009

	Participants (n=42-47)		**Comparisons (n=59-66)**		**Participants – Comparisons Comparison**			
PAI Item or Category	**Mean**	***SD***	**Mean**	***SD***	**Diff.**	***t***	***df***	***d***
How much do you enjoy doing things with technology?	3.70	0.62	3.35	0.72	0.35	2.74**	106	0.52
How much more likely are you to get a good job, if you learn to use technology?	3.64	0.62	3.26	0.87	0.38	2.59*	101	0.48
How well do you concentrate when you use technology?	3.39	0.58	3.02	0.91	0.37	2.47*	107	0.47
How much harder do you work when you use technology?	3.27	0.72	2.70	1.03	0.57	3.38**	106	0.63

[1] Responses were placed on a 4-point scale ranging from 1 (*not at all*) to 4 (*very much*). *Do not know* responses were omitted from the analyses.

PAI Item or Category	Participants (n=42-47)		Comparisons (n=59-66)		Participants – Comparisons Comparison			
	Mean	*SD*	Mean	*SD*	Diff.	*t*	*df*	*d*
How much does using technology increase your ability to learn new things?	3.57	0.62	3.13	0.81	0.44	3.06**	107	0.60
How important is it for you to learn about technology?	3.64	0.57	3.05	1.05	0.59	3.71***	100	0.67
Positive Feelings about Technology category (9 items)	3.53	0.41	3.22	0.57	0.31	3.41**	111	0.61
How much longer does it take you to finish schoolwork when it involves technology?	1.81	0.98	2.61	1.05	- 0.80	-3.88***	100	**0.79**
How easily frustrated do you get with technology?	2.20	0.84	2.65	1.07	- 0.45	-2.45*	106	0.46
How much would you rather NOT use technology?	1.36	0.69	2.05	1.11	- 0.69	-3.96***	105	0.73
How difficult is it for you to use technology?	1.54	0.75	1.97	0.99	- 0.43	-2.45*	108	0.48
How much does technology scare you?	1.23	0.56	1.71	1.11	- 0.48	-2.95**	100	0.52
How much harder is it for you to learn new things when using technology?	1.49	0.59	2.14	0.97	- 0.65	-4.36***	104	**0.79**
How much less do you enjoy school activities if they involve technology?	1.51	0.84	2.06	1.02	- 0.55	-3.08**	104	0.58
Negative Feelings about Technology category (8 items)	1.60	0.45	2.20	0.70	- 0.60	-5.44***	110	**0.99**
How much has Digispired increased your interest in science or technology activities?	2.83	1.02	2.08	1.12	0.75	3.50**	103	0.70
Enrollment in STEM-related School Courses category (all 4 individual items were significant)	3.19	0.77	2.74	0.94	0.45	2.72**	111	0.52

Note. Response options: 1 = not at all; 2 = a little; 3 = somewhat; 4 = very much.
*p < .05. **p < .01. ***p < .001.

In order to ascertain changes among participants, key indicators from the PAI are highlighted in Tables 4 and 5 by year of instrument administration and gender. These are aligned with the indicators reported in the 2007 and 2008 data summaries for ease of comparison.

Table 4. Key Positive Indicators from the PAI: Percentage of Participants Reporting "Somewhat" or "Very Much"

Participant Attitudes and Interests Item	2007		2008		2009	
	Female	Male	Female	Male	Female	Male
Enjoy doing things with technology	75.0	90.5	92.9	90.9	88.2	100.0
Are more likely to get a good job after learning how to use technology	75.0	87.8	82.1	93.2	87.5	96.1
Important to learn about technology	75.0	86.5	82.1	86.3	93.8	96.4
Digispired increased interest in computer, science, or technology courses	63.6	70.2	64.3	77.3	52.9	82.8

Table 5. Key Negative Indicators from the PAI: Percentage of Participants Reporting "Somewhat" or "Very Much"

Participant Attitudes and Interests Item	2007	2008	2009

	Female	Male	Female	Male	Female	Male
Get nervous when working with technology	22.7	21.2	17.9	29.4	5.9	13.8
Get easily frustrated with technology	38.7	36.5	39.3	38.6	23.5	25.0

Independent-samples *t* tests were used to determine whether differences existed between participants' responses in 2007 and 2009. PAI data for both years were available only from Halifax and Hopewell school divisions; therefore, the findings are relevant to those divisions only. There were few significant differences on individual items and no significant differences on composite categories. Compared to 2007, respondents in 2009 were significantly less likely to enjoy computer or video games or to "play around" with science or technology for fun. However, they were also significantly less likely to feel that technology lessened their enjoyment of school activities. See Table 6 for statistical details.

Table 6. PAI Items/Categories Showing Significant Differences between 2007 and 2009

	2009 (n=41-46)		2007 (n=53-56)		2009 - 2007 Comparison			
PAI Item or Category	**Mean**	***SD***	**Mean**	***SD***	**Diff.**	***t***	***df***	***d***
How much do you enjoy computer or video games?	3.61	0.75	3.91	0.35	- 0.30	-2.49*	92	0.54
How much less do you enjoy school activities if they involve technology?	1.51	0.84	1.94	1.18	- 0.43	-2.10*	93	0.42
Other than video games, how often do you "play around" with science or technology for fun?	2.57	0.94	2.95	0.90	-0.38	-2.09*	100	0.42
How much has Digispired increased your ability to work well with others?	2.78	1.01	3.26	0.92	- 0.48	-2.42*	92	0.50

Note. Response options: 1 = not at all; 2 = a little; 3 = somewhat; 4 = very much.
*p < .05.

Using the 2009 PAI data, independent-samples *t* tests were carried out to determine whether there were gender differences on any items or categories of items. Boys tended to have more positive mean scores than girls. However, as in 2008, gender differences were statistically significant for only a few individual items. For the composite categories, males were significantly more likely than females to have positive feelings about technology, participate in technology-related activities, and have intentions to enroll in STEM-related courses. The significant gender differences are presented in Table 7. Most of the effect sizes (Cohen's *d*) of these significant differences are medium or large. The findings that males enjoyed and played video games more than females are also similar to those in 2008. These findings may have implications for *Digispired* program outcomes, if it is presumed that interest in computer or video games is a key motivator—or mediating outcome—theoretically linking program activities and more distal outcomes such as participation in STEM-oriented courses in high school or pursuit of STEM careers.

Table 7. PAI Items/Categories Showing Significant Gender Differences in 2009

	Females (n=16-17)		Males (n=29-30)		Males - Females Comparison			
PAI Item or Category	**Mean**	***SD***	**Mean**	***SD***	**Diff.**	***t***	***df***	***d***
How much do you enjoy computer or video games?	3.12	0.99	3.90	0.31	0.78	3.15**	18	1.06
Positive Feelings about Technology category (9 items)	3.35	0.48	3.64	0.34	0.29	2.22*	25	0.70
How often do you play video games?	2.63	0.72	3.63	0.56	1.00	5.28***	44	1.55
Other than video games, how often do you "play around" with science or technology for fun?	2.18	0.81	2.79	0.94	0.61	2.26*	44	0.70
Participation in Technology category (4 items)	2.41	0.62	2.96	0.70	0.55	2.71*	45	0.83

PAI Item or Category	Females (n=16-17)		Males (n=29-30)		Males - Females Comparison			
	Mean	***SD***	**Mean**	***SD***	**Diff.**	***t***	***df***	***d***
How likely are you to take computer, science, or technology courses in high school?	3.06	0.93	3.40	0.86	0.54	2.38*	43	0.38
Enrollment in STEM-related School Courses category (4 items)	2.88	0.78	3.37	0.72	0.49	2.18*	45	0.65
Interest in scientific research or engineering as a future career	2.25	1.07	3.11	0.97	0.86	2.71*	41	0.84

Note. Response options: 1 = not at all; 2 = a little; 3 = somewhat; 4 = very much.
*p < .05. **p < .01. ***p < .001.

Notable Findings from Participant Attitudes and Interests Data

- For the *Digispired* program as a whole, there was a significant difference between participant and comparison ratings of how important it was for them to "learn about technology." It was significantly more important to *Digispired* participants than the comparison group.

- *Digispired* participants had significantly less negative feeling about technology than the comparison group.

- Participants reported lower ratings than their comparison counterparts to the following items: "how much longer does it take you to finish schoolwork when it involves technology;" "how much would you rather NOT use technology;" and "how much harder is it for you to learn new things when using technology."

- When comparing male and female participants across the three years, males reported a steady increase in how much they "enjoy doing things with technology" across all three years. Females, however, indicated that they "enjoyed doing things with technology" less in 2009 than in 2008. The same pattern is true for the question, "*Digispired* increased interest in computer, science, or technology courses."

- Across the three years, both males and females showed steady increases in their agreement with the following statements: "I am more likely to get a good job after learning how to use technology" and "It is important to learn about technology."

- Females reported a steady decline in how much they agreed with the following statements: "I get nervous when working with technology" and "I get easily frustrated with technology." Overall, males showed a decrease in how much they agree with those statements from 2007 to 2009; however, they most agreed with those statements during the 2008 survey session.

- Males were significantly more likely than females to have positive feelings about technology, participate in technology-related activities, and have intentions to enroll in STEM-related courses.

Participant Knowledge and Skills

The *Participant Knowledge and Skills (PKS) assessment* was administered to *Digispired* participants in 2007, 2008, and 2009; and administered to the comparison students in 2007 and 2009. Complete PKS data for both groups are included in Appendix F. Descriptive statistics for each group are illustrated in Table 8.

Table 8. PKS Survey Percent Items Correct

PKS Administration Group	N	Minimum	Maximum	Mean	Std Dev
2007 Comparison Group	41	11	85	54.38	18.47
2007 *Digispired* Participants	89	19	96	63.75	18.06
2008 *Digispired* Participants	81	0	96	75.54	15.39
2009 *Digispired* Participants	46	37	89	77.21	10.90
2009 Comparison Group	73	4	81	48.25	21.61

For the 2009 data, independent *t*-tests found that the differences in the mean of scores achieved by *Digispired* participants (77.21%) and the mean of comparison group students' scores (48.25%) were statistically significant, suggesting that *Digispired* students were different from their classmates (t [117] = -8.429, p = .000). It is important to note that the comparison group for 2009 was not the same comparison group from 2007. Independent *t-tests* found that there were no significant differences between the two control groups (t [112] = 1.529, p = .129). This statistic argues that even though the comparison groups were not composed of the same individuals, the groups were similar enough to provide a reasonable comparison. Given the 2009 data, it can be said with some confidence that *Digispired* participants are different from their comparison peer—at least in terms of the computer knowledge and skills assessed by the PKS. Specifically, *Digispired* participants are significantly more knowledgeable about technology and related skills. This finding is important, particularly given the fact that the two groups were statistically similar before implementation of the *Digispired* program.

Additionally, differences in the measured scores of *Digispired* participants' PKS scores in 2007 (63.75%) and in 2009 (77.21%) are indeed statistically significant (t [133] = 4.632, p = .000). This means that the pre-participation and post-participation differences, while not absolutely attributable to *Digispired* program activities, are large enough that they are not likely explained away by variances occurring naturally among group members. Thus, participation in the *Digispired* program seems to have increased students' knowledge and skills relevant to technology.

Figure 1 examines differences among the *Digispired* participants for all three years. Distributions of PKS scores among the *Digispired* group and comparison group are provided in Figure 2. Male and female comparisons were not conducted because gender was not asked on the PKS.

Notable Findings from Participant Knowledge and Skills Data

- *Digispired* participants have significantly improved their computer knowledge and skills, at least as they are assessed by the PKS. The *Digispired* participants showed significant increases in their PKS scores from 2007 to 2009.

- For the 2009 data, *Digispired* participants scored significantly better than the comparison group, suggesting, with some confidence, that *Digispired* participants are more knowledgeable about technology their comparisons—at least in terms of the computer knowledge and skills assessed by the PKS. The groups were not significantly different before the *Digispired* program.

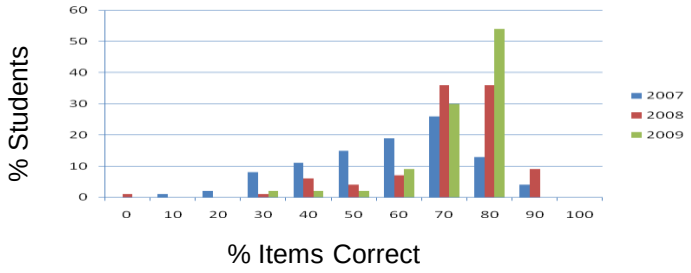

Figure 1. Digispired Participants PKS Score Distribution in Percent, 2007 to 2009

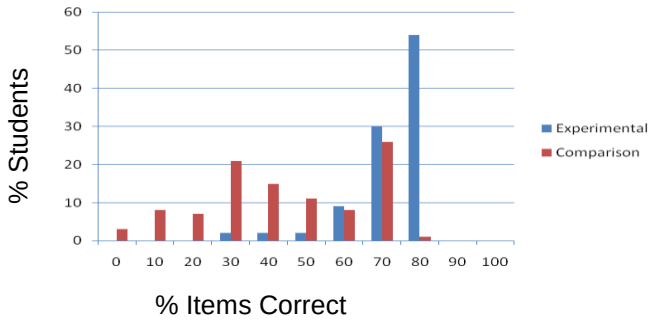

Figure 2. Comparison Group and Digispired Participants PKS Score Distribution in Percent, 2009

Conclusions and Summary

The most notable success of the program was observed in the area of improving students' knowledge and skills. From 2007 to 2009, participating students' knowledge of technology and the skills required to use technology successfully increased significantly. Mean scores on the assessment increased steadily over the 3 years of the project. In 2009, participating students also demonstrated significantly better knowledge and skills than their comparison peers.

At the close of the project, participating students also held attitudes toward technology that were significantly more positive than those held by their comparison peers. Among other factors, *Digispired* students were more likely to believe that it was important to learn about technology, to be less scared of or frustrated by technology, to report that technology increased their ability to learn new things, to report being more likely to enroll in STEM-related courses, and to have more positive feels toward technology in general. *Digispired* students also reported a much greater interest in pursuing careers in scientific research or engineering than their comparison peers (59% to 45%). Participants were more certain about their post-high school plans than non-participants; they primarily planned to attend 4-year college or university programs (78% versus 49% of comparison students).

Students' comments indicate that they enjoyed the program, for the most part, and that they increased their knowledge and skills through their participation. Students enjoyed doing hands-on projects and appreciated working in groups and learning from their peers. The Lego Robotics competition was popular with several students, as were the field trip experiences (which students also saw as opportunities to learn what they would like to have in an institution of higher education). Nearly all students believed that learning about technology would help them in their future education and careers (even if it did not seem relevant to their lives at the moment). It is important to note that in addition to feeling more confident in mathematics and science, students reported other important and, perhaps, unintended impacts of the program including increased patience (especially in peer workgroup situations) and increased maturity.