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The Impact of Think Through Math© Usage on Middle School Students' Mathematics Achievement

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In an era of accountability and high-stakes testing, standardized assessments have become a significant mechanism with which to gauge student learning. Much research has shown that technology-based resources, such as computer software and online instructional programs, are valuable supplemental tools that support student learning and influence student achievement in mathematics at all grades levels (Foster, Anthony, Clements, Sarama, & Williams, 2016; Kiriakidis & Geer, 2014; Securro, Jones, Cantrell, & Blackwell, 2006). While these studies have demonstrated clear benefits associated with use of technology-based resources as a supplement to mathematics instruction, use of these resources also have the potential to be cost- and time-prohibitive for schools and teachers (Clark & Whetstone, 2014). Moreover, how teachers perceive the need for these resources may have an effect on fidelity with usage (Martindale, Pearson, Curda, & Pilcher, 2005). According to Martindale et al., teachers are more likely to incorporate the use of technology-based supplemental resources when they "have the time" or "perceive the need" (p. 357).

Background Context

In Texas, student performance with the state-mandated curriculum is currently appraised annually through administration of State of Texas Assessments of Academic Readiness (STAAR) program (Texas Education Agency, 2016a). Specifically within the content area of mathematics, students are assessed in Grades 3-8 and complete an end-of-course (EOC) assessment for Algebra I. Resulting from state legislation, Texas enacted the Student Success Initiative (SSI), which has specified that students in Grades 5 and 8 who take these STAAR mathematics assessments must receive a passing grade in order to progress to the next grade level (Texas Education Agency, 2016b). In order to ensure students perform well on these required STAAR mathematics assessments, educators actively seek effective supplemental resources that support student learning and impact student performance positively.

As part of the Texas Students Using Curriculum Content to Ensure Sustained Success (SUCCESS) program, Think Through Math© was selected as one of the state-funded vendors to support student achievement in mathematics through the use of computerized interactive programs (Texas Education Agency, 2016c). Consequently, Think Through Math© has become an increasingly popular resource among a large number of school districts in Texas (Think Through Learning, Inc., 2016b). Designed as an adaptive instructional tool, Think Through Math© provides students with access to supplemental resources that align with the state-mandated curriculum within a supportive web-based environment accessible both in school and at home. Unlike traditional software supplemental resources for mathematics, Think Through Math© utilizes a scaffolded approach to instruction that includes many layers of support, including immediate and corrective feedback and access to certified math instructors.

Think Through Math© is currently a state-supported technology-based resource for mathematics instruction in Texas. The provider of Think Through Math© has conducted and published several case studies that have suggested a link between usage of this technology-based resource and improved student performance in mathematics (Think Through Learning, Inc., 2016a). However, at the time of the present study, research and relevant literature independent of this provider was not available.

Theoretical Orientation

The theoretical orientation of this study was situated in concepts that underlie Cognitive Load Theory (Chandler & Sweller, 1991; Paas, Renkl, & Sweller, 2003; Sweller, 1988) and its application to technology-based supplemental resources for mathematics (Kibrick, 2011). Sweller (1988) posited that "cognitive effort expended during conventional problem solving leads to the problem goal, not to learning" (p. 283). However, the teaching of mathematics has chiefly employed conventional problem solving as the predominant instructional approach for learning. Sweller argued that this approach was ineffective and poses cognitive loads on learners that may "impede skill acquisition" (Chandler & Sweller, 1991, p. 294). With respect to instructional design, Sweller contended that instruction must reduce superfluous cognitive loads within the working memory of learners. By doing so, this reduction creates space for the addition of resources that promote comprehension and enhance the development of mathematical understandings (Paas et al., 2003).

Kibrick (2011) applied principles of Cognitive Load Theory to the instructional design of technology-based supplemental resources for mathematics. According to Kibrick, these resources should levy cognitive effort from students, rather than cognitive load. In other words, technology-based supplemental resources for mathematics should present learning experiences that provide students with "a desirable level of difficulty such that they struggle through the task without the task demands exceeding their working memory" (p. 3). With these concepts regarding Cognitive Load Theory in mind, the purpose of the present study was to determine the impact of Think Through Math© usage on middle school students' performance with state-mandated standardized assessments in mathematics.

Methodology

Research Context

The present study was conducted in a north Texas school district during the 2015-2016 school year. Throughout the school year, school district officials encouraged campus administrators and teachers to utilize Think Through Math© as a supplemental instructional tool with their students. Upon periodic viewing of Think Through Math© district-wide usage reports, school district officials identified two middle school campuses that were promoting frequent usage of Think Through Math© among their students who were enrolled in Grades 7 and 8. Based upon this data, school district officials sought to explore the impact of Think Through Math© usage on middle school students' performance with STAAR mathematics assessments.

Data Collection and Analysis

To achieve the purpose for this analysis, data were collected from Think Through Math© reports for each middle school user (N = 259). As shown in Table 1, individual user reports provided information for sixteen aspects of program usage (Think Through Learning, Inc., n.d). Results from the 2015-2016 STAAR mathematics assessments were also collected, which included the STAAR scale score for each middle school student.

Data were analyzed using a multiple linear regression analysis conducted with IBM SPSS Statistics 22 software. In this analysis, STAAR scale scores were designated as the dependent variable and the information obtained from Think Through Math© reports were operationalized and designated as independent predictor variables. Missing values in each data set were treated by excluding cases pairwise. The following null hypothesis was established prior to the analysis: Think Through Math© usage does not have an impact on middle school student performance with STAAR mathematics assessments.

The data set was checked initially to ensure that all assumptions for multiple regression analyses were met (Osborne & Waters, 2002). This analysis of data revealed the presence of multicollinearity, which identified correlations among the following seven independent predictor variables: Lessons Attempted, Total Lessons Passed, Lessons Passed by Pre-Quiz, Pre-Quiz Average, Post-Quiz Average, Problems Attempted, and Earned Points. A closer look at these variables demonstrated that each provided information related to usage with the Think Through Math© lessons. Due to redundancy of information, Lessons Attempted was retained and the other six predictor variables (i.e., Total Lessons Passed, Lessons Passed by Pre-Quiz, Pre-Quiz Average, Post-Quiz Average, Problems Attempted, and Earned Points) were removed from the model. After these revisions were made, a secondary analysis confirmed that all assumptions for a multiple regression analysis were satisfied.

Table 1

Description of Information Generated from Think Through Math© Individual User Reports

Information	**Description**
Placement Test Performance Level	Performance level of the user resulting from the adaptive placement test. Possible performance levels are: Below Grade Level, On Grade Level, and Above Grade Level.
Most Recent Performance Level	Performance level of the user resulting from the most recent benchmark test. Possible performance levels are: Below Grade Level, On Grade Level, and Above Grade Level.
Lessons Attempted	The number of lessons the user has attempted.
Total Lessons Passed	The total number of lessons that a user has completed successfully by either (a) earning 70% or higher on the post-quiz or (b) earning 80% or higher on the pre-quiz.
On Grade Level Pass Rate	The percentage of on grade level lessons that a user has completed successfully.
Below Grade Level Pass Rate	The percentage of below grade level lessons that a user has completed successfully.
Lessons Passed by Pre-Quiz	The lessons that a user skipped by earning 80% or higher on the pre-quiz.
Pre-Quiz Average	The mean of a user’s pre-quizzes.
Post-Quiz Average	The mean of a user’s post-quizzes.
Problems Attempted	The average number of problems that a user completed.
Earned Points	The average number of points that a user earned.
Math Helps	The average number of times that a user accessed the “Help” feature during guided learning within their lessons.
Live Helps	The average number of times that a user accessed the “Live Help” feature during guided learning within their lessons.
Total Math Time	The total time in hours and minutes that a user has spent in lessons.
School Time	The total time in hours and minutes that a user has spent in lessons during school hours.
Evening/Weekend Time	The total time in hours and minutes that a user has spent in lessons on weekdays between 6pm and 7am and all day Saturday and Sunday.

Results

Using the enter method, it was found that Think Through Math© usage explained a significant amount of variance in middle school student performance (*n* = 220) on the STAAR mathematics assessments ($F(10, 209) = 48.52$, $p = 0.00$), with an R^2 of .699. These findings suggested that the model accounts for approximately 70% of variance in the dependent variable than would be explained by chance. Based upon this finding, the null hypothesis was rejected. As shown in Table 2, further analysis revealed five positive, statistically significant relationships with Think Through Math© predictor variables:

- Placement Level ($\beta = .19$, $t(219) = 2.98$, $p = .00$);
- Most Recent Benchmark ($\beta = .30$, $t(219) = 4.52$, $p = .00$);
- Lessons Attempted ($\beta = .25$, $t(219) = 5.47$, $p = .00$);
- On Grade Level Pass Rate ($\beta = .36$, $t(219) = 4.84$, $p = .00$); and
- Below Grade Level Pass Rate ($\beta = .13$, $t(219) = 2.02$, $p = .00$).

Table 2

Statistical Results

	n	*M*	*SD*	*β*	*t*	*p*
STAAR Scale Score	220	1709.10	137.26			
Placement Performance Level	220	2.65	1.02	0.19	2.98	.00
Most Recent Benchmark Performance Level	220	2.84	1.11	0.30	4.52	.00
Lessons Attempted	220	72.15	38.97	0.25	5.47	.00
On Grade Level Pass Rate	220	0.71	0.23	0.36	4.84	.00
Below Grade Level Pass Rate	220	0.84	0.16	0.13	2.02	.04
Math Helps	220	27.90	34.16	-0.62	-1.16	.25
Live Helps	220	1.76	4.39	0.03	0.57	.58
Total Math Time	220	11:50	7:13	-0.02	-0.52	.61
School Time	220	13:20	6:27	0.01	0.34	.74
Evening/Weekend Time	220	6:46	6:00	-0.10	-2.50	.01

Discussion

The purpose of this study was to explore the impact of Think Through Math© usage on middle school student performance with the annual standardized STAAR mathematics assessments. A multiple regression analysis was conducted and produced findings that demonstrate high levels of usage with the Think Through Math© program accounted for a significant amount of variance in student performance on the state-mandated annual standardized assessment for mathematics. Based upon these findings, we have surmised that Think Through Math© usage had a significant impact on middle school students' performance with STAAR mathematics assessments.

Results from this analysis also revealed five statistically significant findings among the following predictor variables: Placement Level, Most Recent Benchmark, Lessons Attempted, On Grade Level Pass Rate, and Below Grade Level Pass Rate. Each of these predictor variables describe specific program usage aspects associated with the Think Through Math© program, which further corroborates the positive impact that Think Through Math© usage had on middle school students' performance with their annual STAAR mathematics assessments. These results align with previous studies that have presented similar favorable findings related to the use of technology-based supplemental resources among students at the middle school level (e.g., Chappell, Arnold, Nunnery, & Grant, 2015; Martindale et al., 2005; Nunnery & Ross, 2007; Securro et al., 2006; Ysseldyke & Bolt, 2007).

Recommendations

As schools continue to utilize technology-based supplemental resources as tools that promote student achievement, it is important that school leaders exercise fidelity of implementation (Protheroe, 2008). According to Protheroe, "Even programs that research demonstrates can have a strong positive impact on student learning must be put into practice every day in the way developers intended" (p. 38). With this in mind, we recommend that school leaders recognize the importance of providing teachers with training and professional development for newly adopted technology-based supplemental resources (Clark & Whetstone, 2014). These trainings should seek to familiarize teachers with the components and structure of district-supported resources (Crawford, Carpenter II, Wilson, Schmeister, & McDonald, 2012).

School leaders must also recognize that fidelity of implementation is largely influenced by teacher beliefs and perceptions (Clements, Sarama, Wolfe, & Spitler, 2015). Therefore, teachers must perceive the technology-based resource as one that will enhance student learning (Clark & Whetstone, 2014). Thus, school leaders must make intentional efforts to explore the impact that technology-based supplemental resources has on student academic performance, and share these findings with teachers. As noted by Clements et al. (2015), teachers are more likely to exhibit "sustained fidelity of implementation to a program that has demonstrated improved child achievement" (p. 445).

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