THE UNIVERSITY OF UTAH
UTAH EDUCATION POLICY CENTER

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Learning Mathematics with Technology in Utah

An Evaluation of Student Attitudes and Perceptions of Math Personalized Learning Software

PREPARED BY THE UTAH EDUCATION POLICY CENTER ON BEHALF OF THE UTAH STEM ACTION CENTER

FOR MORE INFORMATION ON THIS REPORT:
Amy Auletto, Research and Evaluation Associate
Andrea K. Rorrer, Director

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The UEPC informs, influences, and improves the quality of educational policies, practices, and leadership through research, evaluation, and technical assistance. Through our research, evaluation, and technical assistance, we are committed to supporting the understanding of whether educational policies, programs, and practices are being implemented as intended, whether they are effective and impactful, and how they may be improved and scaled-up, and become sustainable.

Please visit our website for more information about the UEPC.

http://uepc.utah.edu

Andrea K. Rorrer, Ph.D., Director
Phone: 801-581-4207
andrea.rorrer@utah.edu

Cori Groth, Ph.D., Associate Director
Phone: 801-581-4207
cori.groth@utah.edu

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Introduction

The Utah STEM Action Center (AC), a division of the Utah Department of Heritage & the Arts, is an organization that seeks to advance STEM education best practices in Utah.[1] In 2013, the Utah Legislature passed House Bill 139[2] (HB 139), which created the STEM AC. According to the bill, the primary goal of the STEM AC is to provide STEM education and digital learning tools to support teacher professional development and excite students about STEM. The bill mandated the STEM AC act as a research and development center for education-related instructional technology. In 2014, Utah's Legislature passed House Bill 150,[3] which expanded the scope of the STEM AC's education-related technology activities and provided ongoing appropriation for the STEM AC from the general fund.

K-12 Math Personalized Learning Software Grant

The K-12 Math Personalized Learning Software Grant is a cornerstone of the STEM AC's education initiatives. The purpose of the K-12 Math Personalized Learning Software Grant is to provide students in kindergarten through grade 12 with access to math personalized learning software to improve student outcomes and math literacy[4]. By increasing student awareness, engagement, interest, and perceived utility of math, the digital math software programs are also expected to improve student math performance. School districts or charter schools apply to STEM AC for grant funds to purchase licenses that provide students and educators access to approved digital math software programs. The approved list of digital math programs is updated annually.

In 2016, the STEM AC contracted with the Utah Education Policy Center (UEPC) to conduct a five-year evaluation of the K-12 Math Personalized Learning Software Grant. The UEPC's evaluation of the grant program focuses on program outcomes across three domains: teacher knowledge, practice, and outcomes; student learning as measured by standardized math test scores; and student attitudes and perceptions—the focus of this particular report.

For more information on the other two domains of our digital math evaluation, we encourage readers to explore the 2020 *Teaching Mathematics with Technology in Utah: An Evaluation of Teacher Knowledge, Practices, and Outcomes Using Mathematics Personalized Learning Software*[5] and *Impact of K-12 Math Personalized Learning Software on Student Achievement.*[6]

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[1] https://stem.utah.gov/about/

[2] https://le.utah.gov/~2013/bills/static/HB0139.html

[3] https://le.utah.gov/~2014/bills/static/HB0150.html

[4] K-12 Math Personalized Learning Software Grant, https://stem.utah.gov/grants/k-12-math-personalized-learning-software-grant/

[5] Onuma, F. J., Rorrer, A. K., Pecsok, M., & Weissinger, K. (2020). *Teaching Mathematics with Technology in Utah: An Evaluation of Teacher Knowledge, Practices, and Outcomes with Using Mathematics Personalized Learning Software.* Utah Education Policy Center: Salt Lake City, UT.

[6] Owens, R., Rorrer, A., Ni, Y., Onuma, F., Pecsok, M., & Moore, B. (2020*). Longitudinal Evaluation of the Math Personalized Learning Software Grant Program.* Salt Lake City, UT: Utah Education Policy Center.

As a part of our evaluation of the K-12 Math Personalized Learning Software Grant, the UEPC administers an annual survey, the UEPC K-12 Math Personalized Learning Software Student Survey, to students in grades 3-12 who use math personalized learning software provided through a STEM AC-provided software license. Historically, this survey has asked students about the frequency with which they use math software and their attitudes toward math and math software. The 2020 version of the UEPC K-12 Math Personalized Learning Software Student Survey, which was administered in spring of 2020, was expanded to include additional survey items focused on student perceptions of how teachers integrate math software into classroom learning experiences. The findings from this survey are the focus of this report.

About the Math Personalized Learning Software Providers

Through the STEM AC's K-12 Math Personalized Learning Software Grant, six personalized learning software programs were available in 2019-2020: ALEKS, Imagine Math, ST Math, i-Ready, Mathspace, and DreamBox. These programs are geared toward different grade levels and approach the goal of providing math personalized learning experiences for students in unique ways. *Table 1. Descriptions of K-12 Math Personalized Learning Software Programs* provides a brief summary of the six programs of interest in this survey.

Table 1. Descriptions of K-12 Math Personalized Learning Software Programs

Personalized Learning Software Program	Grades Served	Description
ALEKS (Assessment and Learning in Knowledge Spaces)	K-12	ALEKS is a web-based software produced by McGraw Hill. The program uses adaptive questioning, focused instruction, and reassessment to ensure retention of new skills.[7]
Imagine Math	PreK-8	Imagine Math is a supplemental program that seeks to develop students' ability to communicate in the language of mathematics and make connections.[8]
ST Math	Pre-K-8	ST Math is a visual instruction program with a focus on spatial-temporal reasoning.
i-Ready	K-8	i-Ready is a program that uses personalized instruction and learning games; also provides teachers with tools for instruction.[9]
Mathspace	6-12	Mathspace is a program that uses personalized learning, interactive textbooks, and step-by-step feedback to help "high achievers" and "those who struggle."[10]
DreamBox	K-8	DreamBox is an adaptive K-8 program that meets student at all levels, from intervention to enrichment, and offers instruction in both Spanish and English.[11]

[7] See https://www.aleks.com/about_aleks for more information on ALEKS.

[8] See https://www.imaginelearning.com/math for more information on Imagine Math.

[9] See https://www.curriculumassociates.com/products/i-ready for more information on iReady.

[10] See https://mathspace.co/us for more information on Mathspace.

[11] See https://www.dreambox.com/ for more information on DreamBox.

Report Organization

In our introduction, we described the STEM AC's Math Personalized Learning Software Grant and the software providers available to students through the grant during the 2019-2020 school year. In the remainder of this report, we provide a review of relevant research in the areas of students' attitudes toward math and students' perceptions of technology in order to provide context and situate this study's findings in the literature base. We then explain the purpose of this study and our corresponding methodology, including information about the design and administration of our survey instrument. In the remaining sections of the report, we present our findings from five evaluation questions, pertaining to the characteristics of survey respondents, the nature and prevalence of math personalized learning software use, the integration of math personalized learning software into classroom learning experiences, students' attitudes and perceptions, and relationships among engagement with math software (frequency of software use and integration with classroom learning experiences) and students' attitudes and perceptions using correlational analysis. We conclude with a summary of our findings and a discussion of considerations for the K-12 Math Personalized Learning Software Program.

Background Research

Numerous studies have explored the impact of math personalized learning software on student achievement outcomes (Cornelius, 2013; Pane et al., 2010; Pane et al., 2014; Wang & Woodworth, 2011). Yet, these studies did not attend to students' perceptions, attitudes, or beliefs about these software programs. Therefore, we offer a review of literature in two related bodies of research: 1) students' attitudes toward math and the relationship of these attitudes to achievement, and 2) students' perceptions of technology in the math classroom. This report focuses on students' reported experiences with, perceptions of, and attitudes toward math and math personalized learning software. As such, we seek to provide context by reviewing studies with related aims in order to situate our findings. We encourage readers with a broader interest in STEM education or a particular interest in teacher practices to read *Teaching Mathematics with Technology in Utah: An Evaluation of Teacher Knowledge, Practices, and Outcomes Using Mathematics Personalized Learning Software.*[12] For those seeking to learn more about technology and student math achievement, please read our report titled *Impact of K-12 Math Personalized Learning Software on Student Achievement.*[13]

Students' Attitudes toward Math

For more than 50 years, researchers have explored students' attitudes toward mathematics (ATMs), guided by the assumption that math learning is influenced, in part, by a set of affective factors (Gómez-Chacón, 2000; McLeod, 1992; Zan, Brown, Evans, & Hannula, 2006). In a similar vein, teachers have been urged to cultivate productive mathematical dispositions in students (Lappan, 1999), which have been framed as a strand of mathematical proficiency (Kilpatrick, Swafford, & Findell, 2001). Influenced by the field of social psychology, a body of research has explored the relationship between various aspects of ATM (e.g., enjoyment, motivation, and self-confidence to do math; perceived value and utility of math; etc.) and student achievement in math (DiMartino, 2016; Lim & Chapman, 2013). It is important to note that in seminal studies, ATM was rarely explicitly defined (DiMartino, 2016) and definitions continue to vary across studies (Daskalogianni & Simpson, 2000; DiMartino & Zan, 2015). As a reference point, Ma and Kishor (1997) expanded Neale's (1969) definition of ATM as "an aggregated measure of 'a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless'" (p. 632, as cited in Ma & Kishor, 1997) "to include students' affective responses to the easy/difficult as well as the importance/unimportance of mathematics" (p. 27).

A number of studies document a relationship between ATM and math achievement. Ma and Kishor (1997) conducted a meta-analysis of 113 studies on the relationship between ATM and math achievement, which resulted in an overall mean effect size of 0.12, suggesting that the

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[12] Onuma, F. J., Rorrer, A. K., Pecsok, M., & Weissinger, K. (2020). *Teaching Mathematics with Technology in Utah: An Evaluation of Teacher Knowledge, Practices, and Outcomes with Using Mathematics Personalized Learning Software.* Utah Education Policy Center: Salt Lake City, UT.

[13] Owens, R., Rorrer, A., Ni, Y., Onuma, F., Pecsok, M., & Moore, B. (2020*). Longitudinal Evaluation of the Math Personalized Learning Software Grant Program.* Salt Lake City, UT: Utah Education Policy Center.

relationship was positive and "statistically significant but not strong" (p. 39). More recent research has continued to document positive relationships between ATM and achievement (Bouchey & Harter, 2005; Chen et al., 2018; Hammouri, 2004; House & Telese, 2008; Reed, Drijvers, & Kirschner, 2010; Samuelsson & Granstrom, 2007; Stankov & Lee, 2014). In their review of large-scale studies of noncognitive predictors of achievement, Stankov and Lee (2014) found that confidence was highly predictive of achievement gains. Though correlations have been explored extensively, the research base has had difficulty establishing whether there is a causal relationship between students' attitudes and achievement (Hannula, 2012; Ma & Kishor, 1997). Ma and Xu (2004) found that "prior achievement significantly predicted later attitudes across grades 7-12" (p. 273), whereas Chen et al. (2018) suggest that positive attitudes in math have "a unique and significant effect on math achievement independent of general cognitive abilities" (p. 11). Hannula (2012) suggested that this variance in studies of the relationship between ATM and achievement may be due to reciprocal causality. Despite this discrepancy, scholars have continued to endorse studies of students' attitudes toward math under the assumption that a more proper, theoretically established framework and definition of attitude, along with more refined measures, will yield valuable information about students' math learning and achievement (DiMartino & Zan, 2011, 2015; Hannula, 2012). In this study, we explore students' attitudes toward math in order to paint a more complete picture of students' math learning and achievement in Utah.

Students' Perceptions of Technology in the Math Classroom

Extant research tells us that the use of mathematics technology has positive effects on math learning (Bokhove & Drijvers, 2012; Cheung & Slavin, 2013; Li & Ma; 2010). To better understand the relationship between technology and student learning, researchers have encouraged explorations of students' perceptions and experiences of technology integration in the classroom (Li, 2007; Pedretti, Mayer-Smith, & Woodrow, 1998). It is important to note that nearly all identified studies of students' perceptions of technology in math were conducted outside of the United States (note exception: Ichinose, 2010).

A body of research has documented positive student perceptions of technology in math instruction. Li (2007) found that a vast majority of students perceive technology to be "useful and effective for their learning" (p. 391). Students have reported that mobile devices led to more interactive (Bonds-Raacke & Raacke, 2008) and novel learning experiences, contributing to increased motivation and engagement (Baya'a & Daher, 2009). Research also tells us that students believe that technology allows them to see math "in a new light," allowing for more fun and creativity (Li et al., 2016, p. 30), as well as deeper, richer, and more challenging math learning experiences (Gadanidis, Hughes, & Cordy, 2011). In a similar vein, students have endorsed asynchronous online content as effective for their math learning (Ichinose, 2010), allowing them to take more responsibility for their learning and affording them a greater sense of autonomy (Muir & Geiger, 2016).

Math technology alone, however, is not enough. Successful student experiences with math technology require strategic implementation on the part of the instructor (Drijvers, 2016;

Drijvers, Monaghan, Thomas & Trouche, 2015). In the only identified study of students' perceptions of a math learning software, Kuiper and de Pater-Sneep (2014) found that the majority of students preferred to work in their physical math workbook instead of their drill-and-practice software program, citing a lack of autonomy and the rigid structure of the software as the primary deterrent. The authors also documented grade-level differences wherein younger students reported more positive attitudes about using the software than older students. The findings from this study suggest that providing students with math software may be insufficient on its own. There is a need to better understand how math personalized learning software is integrated into, and experienced within, the context of the math classroom.

Purpose

In this study, we seek to offer insight into students' experiences using math personalized learning software provided by STEM AC. The purpose of this report is to provide a rich description of the students who accessed math personalized learning software through the K-12 Math Personalized Learning Software Grant Program and their experiences engaging with this technology.

Specifically, we explore software user characteristics, the nature and frequency of math software use, the extent to which software was integrated into classroom experiences, and students' attitudes and perceptions. We also explore the relationships among software use (frequency and classroom integration) and students' attitudes and perceptions using a correlational analysis.

Our evaluations questions were:

1. What were the characteristics of students who reported using math personalized learning software during the 2019-20 school year?
2. What were the nature and prevalence of math personalized learning software use among Utah students?
   a. How common were particular programs?
   b. With what frequency did students report using programs? How did reported use vary by student characteristics?
3. To what extent did students report that math personalized learning software integrated with their classroom learning experiences? How did this vary across student characteristics?
4. What were students' attitudes toward, and perceptions of, math personalized learning software and math more generally? Specifically:
   a. What were students' attitudes toward math software?
   b. What were students' attitudes toward math as a result of math software?
   c. To what extent did students perceive that their math software was personalized?
   d. What were students' general attitudes of math?
5. Controlling for student characteristics, such as grade level, gender, and honors-course taking, to what extent do the following explain students' attitudes and perceptions of math software?
   a. Frequency of software use during math class
   b. Frequency of software use outside of math class
   c. Integration of software into classroom learning experiences

Method

Survey Instrument and Administration

The UEPC K-12 Math Personalized Learning Software Student Survey included 47 items that were developed with the intention of gathering information about software users' characteristics, how they engaged with math software, and their attitudes toward, and perceptions of, math software and math. While specific survey items and the constructs they measure are discussed in greater detail in our discussion of results, we provide a brief description here of the survey instrument as a whole.

Across the majority of items in the survey, respondents selected responses on a Likert scale that included the following response options: *strongly disagree, disagree, neutral, agree*, and *strongly agree*. The following are two examples of this question type:

- I use (software) to work with other students on math.
- Using (software) made math more interesting.

At other times, respondents indicated their level of agreement on a scale from 1-5. For example, we asked respondents to describe how fun math was on a five-point scale, where 1=not at all fun and 5=very fun. Some items pertained to frequency of software use. For example, we ask students how often they use math software during math class. In these cases, we provided a categorical scale, which included options such as *never, once a month or less, 2-3 times a month*, and *about once a week* as answer choices.

The UEPC K-12 Math Personalized Learning Software Student Survey was administered using a licensed version of Qualtrics, a web-based survey tool, in February-May 2020. No identifiable information was collected from participants. On average, respondents spent 11 minutes completing the survey. Students who had access to math personalized learning software during the 2019-2020 school year through the K-12 Math Personalized Learning Software Grant Program were invited to participate. STEM AC staff disseminated a confidential survey link to teachers and administrators and also made this link available on the STEM AC website. From here, students were typically invited to participate in the survey by their teachers. The survey was intended for all students who accessed personalized math software through a license provided by STEM AC. Surveys of this type are permitted in accordance with FERPA and the evaluation of an instructional program. However, due to the use of an open survey link and the reliance on local schools to distribute the survey link to students, we are unable to determine with certainty whether every user had the opportunity to participate in the survey. As a result, it is not possible to calculate an accurate response rate. That said, specific details about respondents are discussed in further detail in our presentation of results.

Analysis

To analyze survey data, we used summary descriptive statistics, hypothesis testing, confirmatory factor analysis, and ordinary least squares linear regression. While our first evaluation question was answered strictly through the use of descriptive statistics, we briefly describe our approach for the remaining four evaluation questions below:

What were the nature and prevalence of math personalized learning software use among Utah students?	We used two-sample tests of proportion and one-way analysis of variance (ANOVA) tests to identify differences in math software use across student characteristics. This approach allowed us to determine whether or not differences in math software use by gender, grade level, and course-taking were due to chance.
To what extent did students report that math personalized learning software integrated with their classroom learning experiences? How did this vary across student characteristics?	We used confirmatory factor analysis to generate a composite measure that captures this construct. Confirmatory factor analysis allowed us to group similar survey items together.
What were students' attitudes toward, and perceptions of, math personalized learning software and math more generally?	We used confirmatory factor analysis to generate four unique measures of student attitudes and perceptions. The specifics of these four measures are described in more detail as a part of our results.
Controlling for student characteristics, such as grade level, gender, and honors-course taking, to what extent do the following explain students' attitudes and perceptions of math software?	We used ordinary least squares (OLS) regression. This approach allowed us to account for student characteristics that might influence attitudes and perceptions (e.g., gender, grade level, software program, honors-course taking) so as to isolate the extent to which engagement with software explains attitudes and perceptions. We used models that took the following format: $\text{Attitude}_s = \beta_1\text{Female}_s + \mathbf{GradeLevel_s}\beta_2 + \mathbf{Software_s}\beta_3 + \beta_4\text{Honors}_s + \beta_5\text{EngagementwithSoftware}_s + \varepsilon_s$ In the above model, Attitude_s is a student's reported attitude or perception. Female_s, GradeLevel_s, Software_s, and Honors_s control for student gender, grade level, software program, and honors-course taking, respectively. $\text{EngagementwithSoftware}_s$ is the primary predictor of interest. We estimated separate models where this measure indicates either the frequency with which a student used math software or the extent to which software was integrated into their classroom experience. Robust standard errors were used in all models. All analyses were conducted using Stata 16.0, a statistical analysis software program.

Survey Results

Characteristics of Survey Respondents

A total of 33,454 respondents participated in the K-12 Math Personalized Learning Software Student Survey out of a possible ~161,000 students[14] who were provided with licenses to use math personalized learning software by STEM AC. Respondents were those who consented to participating in the survey and indicated that they used one of six math personalized learning software programs (i.e., ALEKS, DreamBox, Imagine Math, Mathspace, ST Math, i-Ready) during the 2019-2020 school year. Summarized in *Table 2. Characteristics of Survey Respondents*, we asked respondents to indicate their gender and grade level; in the case of respondents in grade 8 and above, we also collected information about math coursework. As shown in Table 2, slightly more female respondents than male respondents participated in the survey and respondents were most commonly in grades 6-8 (~43%), followed by grades 3-5 (~38%) and grades 9-12 (~20%). Among respondents in grades 8 and above, respondents most commonly reported taking 8th Grade Math (~36%), followed by Secondary I and Secondary II (~29% and ~21%, respectively). Just over 30% of respondents enrolled in Secondary I, II, and III reported that they were an honors math course.

Table 2. Survey Respondent Characteristics

Respondent Characteristic	%
Gender	
Female	48.7%
Male	47.0%
Other/Prefer Not to Say	4.3%
Grade	
3	10.1%
4	12.9%
5	14.9%
6	14.0%
7	15.8%
8	12.7%
9	10.5%
10	5.4%
11	3.2%
12	0.6%
Math Course (Grade 8 and above)	
8th Grade Math	36.3%
Secondary I	29.1%
Secondary II	20.8%
Secondary III	9.4%
Other	4.6%
In an honors course*	30.3%

*Only respondents in Secondary I, II, and III were asked whether their math course was honors level.

[14] This estimate is based on the number of software licenses issued as of spring 2020.

Nature and Prevalence of Math Personalized Learning Software Use

As illustrated in *Table 3. Math Personalized Learning Software Use,* respondents most commonly reported using ALEKS math software (48%), followed by Imagine Math, ST Math, and i-Ready (15-17%). Relatively few respondents reported using MathSpace or DreamBox.

Table 3. Math Personalized Learning Software Use

Software Program	%
ALEKS	48.3%
Imagine Math	17.0%
ST Math	16.1%
i-Ready	15.0%
Mathspace	2.2%
DreamBox	1.5%

Respondents reported the frequency with which they used math personalized learning software both during and outside of math class. *Table 4. Frequency of Math Personalized Learning Software Use* shows that the majority of respondents are using math software at least once a week during math class (~79%). Yet, use outside of math class is less frequent. Indeed, nearly one-third of respondents reported never using math software outside of math class and just under 35% of respondents reported using math software at least once a week outside of math class.

We contextualize these findings with a brief discussion of the recommendations for usage provided by some math personalized learning software vendors. Although ALEKS, for example, does not provide recommendations for minutes of use per week, the ALEKS website offers examples of implementation strategies enacted by districts across the country, ranging from two to five hours a week.[15] I-Ready currently recommends students use software for 45 minutes each week.[16] ST Math recommends 60 minutes of weekly use for students in grades K-1 and 90 minutes of weekly use for students in grades 2-5.[17] Whiles these guidelines on how much time to spend using math software do not directly translate into frequency of use, students would generally need to use math software at least once a week to meet these recommendations.

To allow for easier interpretation of survey results, we categorized respondents as "frequent users" if they reported using math software at least once a week through the remainder of this

[15] See https://www.ALEKS.com/k12/implementations/popup?_form_=true&parse_list=e*258&parse_request=true&cmscache=parse_list:parse_request#:~:text=Students%20will%20be%20expected%20to,minutes%2C%20four%20days%20per%20week and https://www.aleks.com/k12/implementations/index?_form_=true&parse_request=true&parse_list=h*323&cmscache=parse_list:parse_request

[16] https://www.curriculumassociates.com/products/i-ready/how-it-works

[17] https://dlassets.stmath.com/pdfs/massachusetts/MA-Implementation-Guide-EN-176.pdf

report. As noted below in Table 4, "Frequent users" are those who indicated they use math personalized learning software either "more than 2-3 days a week," "2-3 days a week," or "about once a week."

Table 4. Frequency of Math Personalized Learning Software Use

Frequency	During Math Class	Outside of Math Class
More than 2-3 days a week*	32.0%	8.0%
2-3 days a week*	27.0%	11.9%
About once a week*	20.3%	14.6%
2-3 times a month	7.3%	9.4%
Once a month or less	5.3%	15.1%
Never	3.6%	32.4%

*Respondents who indicated "more than 2-3 days a week," "2-3 days a week," and "about once a week" are collectively referred to as "frequent users" throughout the remainder of this report.

Variation in Math Personalized Learning Software Use by Gender

As summarized in *Table 5. Math Personalized Learning Software by Gender,* we used two-sample tests of proportion and found that there were no statistically significant differences in software use across male and female respondents.

Table 5. Math Personalized Learning Software Use by Gender

Math Personalized Learning Software	Gender		
	Male	Female	Difference
ALEKS	49.3%	50.6%	1.3%
DreamBox	52.1%	47.9%	4.2%
Imagine	49.0%	51.0%	2.0%
Mathspace	48.5%	51.5%	3.0%
ST Math	48.8%	51.2%	2.4%
i-Ready	48.4%	51.6%	3.2%
Total	**49.1%**	**50.9%**	**1.8%**

***p<.001, **p<.01, *p<.05

Turning to frequency of software use, we found differences in the frequency of math software use outside of math class by gender. Here, we used a binary measure where "frequent users" are those who reported using math software at least once a week. In other words, they selected one of the following options: "more than 2-3 days a week," "2-3 days a week," or "about once a week." We conducted two two-sample tests of proportion to compare the proportions of male and female respondents who were frequent software users. Summarized in *Table 6. Frequency of Software Use by Gender*, we found that female students were more likely to be frequent users than male respondents (38% vs. 35%). There were no statistically significant differences by gender in rates of frequent users during math class.

Female students were somewhat more likely to use software frequently outside of math class. Just over 38% of female respondents reported using software frequently versus 35% of male students.

Table 6. Frequency of Software Use by Gender

	% Frequent Users	
	During Math Class	Outside of Math Class
Male	83.3%	34.6%
Female	83.3%	38.1%
Difference	0.0%	3.5%***

***p<.001, **p<.01, *p<.05

Variation in Math Personalized Learning Software Use by Grade Level

Table 7. Math Personalized Learning Software Use by Grade Level demonstrates variation in software use by grade level that aligns with the intended audiences for each program. ALEKS, a K-12 program, was used by respondents across all grade levels with a majority of users in grades 7-9; Imagine Math, ST Math, i-Ready, and DreamBox were used primarily by respondents in grades 6 and below; MathSpace was used primarily by respondents in grades 9-11.

Table 7. Math Personalized Learning Software Use by Grade Level

	Math Personalized Learning Software					
Grade	ALEKS	Imagine Math	ST Math	i-Ready	Mathspace	DreamBox
Target Grade Levels	K-12	PreK-8	PreK-8	K-8	6-12	K-8
3	1%	14%	28%	16%	0%	20%
4	2%	24%	24%	22%	0%	34%
5	4%	24%	29%	28%	0%	11%
6	9%	27%	15%	14%	3%	31%
7	27%	7%	2%	8%	14%	4%
8	22%	3%	1%	7%	3%	0%
9	19%	1%	0%	3%	24%	0%
10	9%	0%	0%	1%	37%	0%
11	6%	0%	0%	0%	15%	0%
12	1%	0%	0%	0%	4%	0%

We also considered whether the frequency with which respondents reported using math software varied by grade level. *Table 8. Frequency of Software Use by Grade Level* summarizes the results of two two-sample tests of proportions where we compared the proportions of elementary respondents (grades 3-8) and secondary respondents (grades 9-12) who reported that they were frequent users of math software during and outside of math class. As illustrated in Table 8, elementary respondents are significantly more likely to be frequent users of math software during math class (85% vs 75%, p<.001), while secondary respondents are significantly more likely to be frequent users outside of class (40% vs. 35%, p<.001).

Table 8. Frequency of Software Use by Grade Level

	% Frequent Users	
	During Math Class	**Outside of Math Class**
Elementary	85.0%	35.0%
Secondary	75.4%	40.1%
Difference	9.6%***	5.1%***

***p<.001, **p<.01, *p<.05

Variation in Math Personalized Learning Software Use by Math Coursework

As illustrated in *Table 9. Math Personalized Learning Software Use by Math Course among Respondents in Grades 8 and Above*, we compared software use by math coursework among respondents in grades 8 and above. In this section, we limit our findings to ALEKS and Mathspace, as these are the only two programs designed for respondents in traditional secondary math courses. We note that a small percentage of students in secondary grade levels reported using software programs designed for K-8 students. For example, 1% of Imagine Math users and 3% of i-Ready users were in grade 9. However, due to these small proportions of students, we focus our analysis of software use by math coursework to ALEKS and Mathspace.

We found that ALEKS was more frequently used among respondents in 8th Grade Math and Secondary I, while Mathspace was used most often by respondents in Secondary II. Rates of honors-course taking were slightly higher among ALEKS users than Mathspace users.

Table 9. Math Personalized Learning Software Use by Math Course among Respondents in Grades 8 and Above

	Math Personalized Learning Software	
Math Course	ALEKS	Mathspace
8th Grade Math	35%	4%
Secondary I	30%	26%
Secondary II	20%	45%
Secondary III	10%	14%
Other	4%	10%
Honors Course*	31%	28%

*Only respondents in Secondary I, II, and III were asked whether their math course was honors level.

To compare frequency of software use by math course, we conducted two one-way analysis of variance (ANOVA) tests to compare the proportion of frequent users across math course both during math class and outside of math class. As shown in *Table 10. Frequency of Software Use by*

Math Course among Respondents in Grade 8 and Above, we found significant variation in frequency of software use in both settings. Respondents in lower levels of math, such as 8th Grade Math and Secondary I, tended to report more frequent software use in class (86% and 82%, respectively). Outside of math class, respondents in Secondary I tended to report the highest rates of use (47%).

Also summarized in Table 10, we used a two-sample test of proportions to compare frequency of use among student in honors and non-honors courses. We found no statistical difference in in-class use but higher rates of use among honors respondents outside of class (49% vs. 38%, $p<.001$).

Table 10. Frequency of Software Use by Math Course among Respondents in Grade 8 and Above

	% Frequent Users	
Math Course	During Math Class	Outside of Math Class
8th Grade Math	85.7%	32.9%
Secondary I	82.3%	47.1%
Secondary II	74.6%	38.7%
Secondary III	60.2%	29.9%
Other	72.1%	39.6%
F-statistic	120.38***	81.49***
Honors Status		
Honors Course	77.0%	48.8%
Non-Honors Course	75.6%	38.2%
Difference	1.4%	10.6%***

*Only respondents in Secondary I, II, and III were asked whether their math course was honors level.
***p<.001, **p<.01, *p<.05

Students who took honors-math courses were more likely to use math software frequently outside of class. Nearly half of students in honors courses use math software frequently versus 38% of students who were not in honors-math courses.

Integration of Math Personalized Learning Software into Classroom Learning Experiences

Through the administration of the UEPC K-12 Math Personalized Learning Software Student Survey, we aimed to better understand from the student's perspective the extent to which math software is integrated into classroom learning experiences. To do this, we used confirmatory factor analysis to identify and group similar survey items that collectively measure respondents' classroom learning experiences with their math personalized learning software. Throughout the remainder of this report, we will refer to this construct as "classroom technology integration."

We included eight survey items in our composite measure of classroom technology integration. In these items, we asked respondents to rate their level of agreement using a five-point Likert scale, where "1" indicated a high level of disagreement and "5" indicated a high level of

agreement. Respondents indicated their level of agreement, for example, with the extent to which they use math software to work with others and the extent to which math software is similar to worksheets or bookwork. These items, including means and standard deviations, are summarized in *Table 11. Summary of Classroom Technology Integration Survey Items.*
The mean level of classroom technology integration reported by students was 2.6 on a scale of 1-5, suggesting that respondents' math software experiences were not particularly well-integrated into their classroom learning experiences. Only two of eight items had mean levels of agreement above a "3" (where "3" indicates a neutral response). These two items were the extent to which math software included interactive content (3.1) and the extent to which respondents felt they could engage in real-world math problems while using their math software (3.2). This finding suggests there may be room for educators to more intentionally integrate math personalized learning software into classroom learning experiences.

The mean level of classroom technology integration reported by students was 2.6 on a scale of 1-5, suggesting that respondents' math software experiences were not particularly well-integrated into their classroom learning experiences. This finding suggests there may be room for educators to more intentionally integrate math personalized learning software into classroom learning experiences.

Table 11. Summary of Classroom Technology Integration Survey Items

Survey Item	Mean	Standard Deviation
(Software) work is just like worksheets or bookwork, except on the computer. (reverse coded)	2.9	1.1
(Software) includes videos, interactions, demonstrations or other content that support my learning.	3.1	1.2
I use (software) to work with other students on math.	2.2	1.1
I use (software) to present or demonstrate my work to the teacher or other students.	2.5	1.2
I do work in (software) that wouldn't be possible without it.	2.6	1.2
Through (software) I can engage in real-world math problems and solutions.	3.2	1.2
I create math problems for other class members using (software).	1.9	1.0
I collaborate with other students or professionals outside of my class using (software).	2.1	1.1
Overall Composite Measure Cronbach's alpha: 0.81	**2.6**	**0.7**

Note: In place of "(software)," personalized text piping was used throughout the survey so as to allow respondents to answer questions pertaining to the specific software they reported using.

Attitudes and Perceptions

Attitudes toward Math Software

We used confirmatory factor analysis to generate a measure of respondents' attitudes toward their math personalized learning software based on five survey items. These items assessed respondents' level of agreement that, for example, they enjoyed using math software, that it was boring, and that it was a waste of time. Throughout the remainder of this report, we will refer to this construct as "attitudes toward math software."

In these items, we again asked respondents to indicate their level of agreement using a five-point Likert scale, where "1" indicated a high level of disagreement and "5" indicated a high level of agreement. The five items included in this construct, along with their means and standard deviations, are summarized in *Table 12. Attitudes toward Math Software.*
The mean attitude toward math personalized learning software was 3.0 on a scale of 1-5, indicating that respondents were generally neutral about their experiences. The lowest rated item in this construct was agreement that respondents enjoyed using math software at home (2.4), while the highest rated item was agreement that using math software was a waste of time (3.5). As noted in Table 12, this item was reverse coded such that higher values indicate disagreement that math software was a waste of time. Collectively, these relatively neutral attitudes toward math software indicate that there may be room to improve user experiences.

Table 12. Attitudes toward Math Software

Survey Item	Mean	Standard Deviation
I like using (software) in school.	3.1	1.3
I like using (software) at home.	2.4	1.3
(Software) is boring. (reverse coded)	2.9	1.3
(Software) is a waste of time. (reverse coded)	3.5	1.3
(Software) made me feel frustrated or discouraged. (reverse coded)	3.2	1.3
Overall Composite Measure	**3.0**	**1.0**
Cronbach's alpha: 0.85		

Note: In place of "(software)," personalized text piping was used throughout the survey so as to allow respondents to answer questions pertaining to the specific software they reported using.

The lowest rated item in this construct was agreement that respondents enjoyed using math software at home (2.4), while the highest rated item was agreement that using math software was a waste of time (3.5, reverse coded).

Attitudes towards Math as a Result of Math Software

We also asked respondents to indicate the extent to which their use of math personalized learning software influenced their attitudes toward math more generally. Using confirmatory factor analysis, we generated a measure of respondents' attitudes toward math due to their math software use based on five survey items. These items assessed respondents' level of agreement that using math software, for example, made math more interesting, more fun, and easier.

In these items, we again asked respondents to indicate their level of agreement using a five-point Likert scale, where "1" indicated a high level of disagreement and "5" indicated a high level of agreement. The five survey items included in this construct, along with their means and standard deviations, are summarized in *Table 13. Attitudes toward Math as a Result of Math Software.*

The mean attitude toward math as a result of math software was 3.0 on a scale of 1-5, indicating that respondents were generally neutral about their experiences. The lowest rated item in this construct was agreement that using math software made math more fun (2.8), while the highest rated items were agreement that using math software helped respondents see that math is useful in everyday life and that software made learning math easier (3.1). Collectively, these findings suggest that, on average, respondents do not feel that math software has either positively or negatively influenced their attitudes toward math.

Table 13. Attitudes toward Math as a Result of Math Software

Survey Item	Mean	Standard Deviation
Using (software) made math more interesting.	2.9	1.2
Using (software) made math more fun.	2.8	1.3
Using (software) helped me see math is useful in everyday life.	3.1	1.2
Using (software) helped me see the importance of math in my long-term plans.	3.0	1.2
Using (software) made learning math easier.	3.1	1.3
Overall Composite Measure Cronbach's alpha: 0.90	**3.0**	**1.1**

Note: In place of "(software)," personalized text piping was used throughout the survey so as to allow respondents to answer questions pertaining to the specific software they reported using.

Perceptions of Personalization as a Result of Math Software

We asked respondents to reflect on the extent to which they felt math software was personalized to meet their needs. Through confirmatory factor analysis, we created a measure of personalization based on four survey items. These items assessed respondents' level of agreement that they were able to work at their own pace, receive support with difficult material, work ahead, and have their learning style accommodated through the use of math personalized learning software.

In these items, we again asked respondents to indicate their level of agreement using a five-point Likert scale, where "1" indicated a high level of disagreement and "5" indicated a high level of agreement. The four items included in this construct, along with their means and standard deviations, are summarized in *Table 14. Perceptions of Personalization as a Result of Math Software.*

On average, respondents scored 3.4 on a scale of 1-5 points, indicating somewhat favorable perceptions of the extent to which math software was personalized. All four items in this construct had a mean value above 3.0, and the highest rated item was agreement that it is possible to work at one's own pace while using math software (mean=3.7). This suggests that self-pacing may be a particularly beneficial feature of math personalized learning software. Collectively, these findings offer some evidence that math software may offer users a personalized learning experience.

Table 14. Perceptions of Personalization as a Result of Math Software

Survey Item	Mean	Standard Deviation
I can work in (software) at my own pace	3.7	1.1
(Software) provides help and support with difficult material	3.3	1.1
(Software) lets me work ahead to more challenging material if something is too easy.	3.4	1.2
(Software) works well with my learning style.	3.2	1.3
Overall Composite Measure Cronbach's alpha: 0.78	**3.4**	**0.9**

Note: In place of "(software)," personalized text piping was used throughout the survey so as to allow respondents to answer questions pertaining to the specific software they reported using.

Math Attitudes

Students' reported math attitudes cannot be specifically attributed to their math personalized learning software use. However, we asked respondents to describe their math attitudes through a set of four survey items (adapted from Yasar, 2014). We asked students to indicate the extent to which they agree math is fun, interesting, useful in everyday life, and something they are good at. Using confirmatory factor analysis, we generated a composite measure of math attitudes based on these four items.

In these items, we again asked respondents to indicate their level of agreement using a five-point Likert scale, where "1" indicated a high level of disagreement and "5" indicated a high level of agreement. The four items included in this construct, along with their means and standard deviations, are summarized in *Table 15. Respondents' Math Attitudes.*
On average, respondents' math attitudes were slightly above neutral, 3.3 points on a scale of 1-5. Although agreement that math is useful and something respondents are good at were slightly higher (3.6 and 3.5, respectively), respondents were relatively neutral about the extent to which

math is fun and interesting (3.1 in both cases). In future analyses, it may be beneficial to assess student math attitudes at the beginning of the school year and end of the school year in order to more accurately attribute these attitudes to math software use.

Table 15. Respondents' Math Attitudes

Survey Item	Mean	Standard Deviation
Math is fun.	3.1	1.2
Math is interesting.	3.1	1.3
Math is useful in everyday life.	3.6	1.2
Math is something I am good at.	3.5	1.2
Overall Composite Measure	**3.3**	**1.0**
Cronbach's alpha: 0.81		

Predicting Attitudes and Perceptions

Finally, we examined the extent to which various predictors of interest—frequent software use during math class, frequent software use outside of math class, and technology integration—predicted respondents' attitudes and perceptions of math personalized learning software. We used OLS regression to control for student gender, grade level, software program, and honors-course taking. In other words, when two students are exactly the same in terms of gender, grade level, software program, and whether or not they are in an honors course, this approach allows us to measure whether attitudes and perceptions are higher for the student who, for example, use software frequently in math class.

Table 16. Frequency of Software Use and Classroom Technology Integration as Predictors of Attitudes and Perceptions contains the results from our regression analyses. As an example of how to interpret this table, the value in the top leftmost corner, "+0.3," indicates that relative to otherwise similar students who used math software infrequently during math class (less than once a week), on average, respondents who used math software frequently (those who indicated "more than 2-3 days a week," "2-3 days a week," or "about once a week"), had perceptions of math personalized learning software that were 0.3 points higher than infrequent users.

A similar interpretation applies to frequency of math software use outside of math class. In the middle column of the top row of Table 16, "+0.4" indicates that, relative to those who infrequently use math software outside of math class, those who used it frequently had perceptions of math personalized learning software that were, on average, 0.4 points higher than infrequent users.

The interpretation for values under the column titled "Classroom Technology Integration" is slightly different. Using the top rightmost value as an example, holding all else equal, every one-point increase in classroom technology integration (on a scale of 1-5) was associated with a 0.8

point increase in perceptions of math personalized learning software. Students who report higher levels of classroom technology integration also have more positive perceptions of their math software.

Across all models, our results were positive and statistically significant (p<.001). These findings suggest that respondents who frequently used math personalized learning software during and outside of math class, as well as those who perceived that math software was integrated into their classroom experiences, had more positive attitudes toward, and perceptions of, their math personalized learning software.

We remind the reader that these results are not causal. That is to say, we cannot confirm that more frequent use or better classroom technology integration *caused* respondents to have more positive perceptions of math software. These analyses only indicate that respondents who used software more frequently or experienced strong classroom technology integration also had more positive perceptions. There are other unobservable factors, such as personal dispositions, that these models cannot account for.

Table 16. Frequency of Software Use and Classroom Technology Integration as Predictors of Attitudes and Perceptions

	Predictors of Interest		
Attitudes and Perceptions	Frequent Software Use During Math Class	Frequency of Software Use Outside of Class	Classroom Technology Integration
Attitudes toward Math Software	+0.3	+0.4	+0.8
Attitudes toward Math as a Result of Math Software	+0.4	+0.4	+0.9
Perceptions of Personalization as a Result of Math Software	+0.3	+0.3	+0.8

Note: All values in this table control for respondent gender, grade level, software program, and honors-course taking. Each value is on a five-point scale. For example, frequent in-class software users report perceptions of math personalized learning software that are, on average, 0.3 points higher than infrequent software users, holding gender, grade level, software program, and honors-course taking constant. All values in this table were statistically significant (p<.001).

As an example of how to interpret this table, "+0.3," indicates that relative to otherwise similar students who used math software infrequently during math class (less than once a week), on average, respondents who used math software frequently (those who indicated "more than 2-3 days a week," "2-3 days a week," or "about once a week"), had perceptions of math personalized learning software that were 0.3 points higher than infrequent users.

Discussion

Summary of Findings

Our analyses of student responses to the UEPC K-12 Math Personalized Learning Software Student Survey revealed a number of noteworthy findings. First, we found variation in the frequency of software use across student groups. Specifically, female students, secondary students, and those taking honors math courses were more likely to be frequent software users outside of math class as compared to male students, elementary students, and student who did not take honors math courses, respectively. In the case of math-course taking of among students in grade 8 and above, we found that students taking 8th grade math used math software during math class most frequently. Among students taking 8th grade math, 86% reported doing so at least once a week versus as few as 60% in the case of other secondary math courses. Outside of math class, students enrolled in Secondary I were the most frequent users of math software outside of class; 47% of Secondary I students used math software outside of class at least once a week versus as few as 30% of students in the case of other secondary math courses. It is not clear from these survey data how much of this variation is due to individual student preferences or motivation as opposed to teachers' instructional decisions.

We also found that, on average, students' perceptions of classroom technology integration were relatively low—2.6 on a scale of 1-5. Within this construct, survey items related to collaboration with peers and educators were particularly low, suggesting that math software use is often an individual activity for students.

Attitudes toward math software and math as a result of software use were, on average, neutral. The mean level across both of these measures was 3.0 on a scale of 1-5. Perceptions of personalization as a result of software use were a bit higher; on average, students reported a 3.4 on a scale of 1-5 for this measure. These findings suggest that while math software is offering a fairly personalized experience to students, students do not always perceive their experiences all that positively.

Finally, we found positive relationships among engagement with math software—frequent use both during and outside of math class and integration of math software into classroom learning experiences—and three measures of students attitudes toward math: their attitudes toward math software, their attitudes toward math as a result of software use, and their perceptions of personalization as a result of math software. These relationships held even after accounting for student gender, grade level, software program, and honors-course taking status. We found that when students use software frequently and when it is integrated into their classroom learning experiences, they also had more positive attitudes. In light of these findings, considerations for the UEPC K-12 Math Personalized Learning Software Grant Program going forward are discussed below.

Considerations for the K-12 Math Personalized Learning Software Grant Program

Encouraging frequent use of math software may be one pathway to developing more positive attitudes toward math software and math.

Given our finding that students who use math software more frequently also have more positive attitudes and perceptions, we recommend that educators encourage regular use of math software. Our findings build upon prior research that has established the relationship between frequent math software use and positive math learning outcomes (Cheung & Slavin, 2013; Li & Ma, 2011). For example, Cheung and Slavin (2013) found that students who used math software at least 30 minutes each week had the greatest learning gains. Similarly, Li and Ma (2011) found evidence that the targeted use of math technology over the course of a term was an effective strategy for boosting math achievement. Findings from our evaluation indicate that students who frequently use math software will experience benefits that extend beyond math learning. Even after controlling for characteristics such as gender, grade level, software program used, and honors-course taking, we found consistent evidence that frequent software users expressed more positive attitudes toward math software, math as a result of software use, and personalization as a result of software use. While the relationship between frequent software use and attitudes is not necessarily causal, it may be the case that when students are in the habit of engaging with math software on a regular basis, they become more comfortable interacting with the technology. Regular use of math personalized learning software may allow students to more easily build upon and retain skills, therefore leading to more positive experiences with the software. These positive experiences, in turn, might shape students' attitudes toward the software and math more generally. Over 90% of respondents indicated that they have a home device on which they can use math software, suggesting that access to technology is unlikely to be a barrier for most students. Therefore, encouragement from educators to both students and their families may be an effective strategy to increase math software use and, in turn, student attitudes and perceptions.

Strengthening the integration of math software into classroom learning experiences may be another pathway to developing more positive attitudes toward math software and math.

Students who reported higher levels of classroom technology integration also had more positive attitudes toward, and perceptions of, math software. Our finding confirms and buildings upon the findings of other scholars who have investigated the use math technology (e.g., Gadanidis, Hughes, & Cordy, 2011; Ichinose, 2010). When students were in greater agreement that their interactions with math software were a part of their classroom learning experiences—for example, that math software allowed them to collaborate with peers and work through real-world math problems in interactive ways—they also reported more positive attitudes and perceptions. Based on this finding, we encourage educators to look for ways to more thoroughly integrate math software into students' classroom experiences. Within our measure of classroom technology integration, the lowest rated survey items were specific to collaboration with peers. Based on this finding, it may be beneficial for teachers to explore ways for students to use math software to learn together more often rather than in isolation. Specifically, teachers might consider matching students together who are working to master similar skills with their math software in order to build upon individual learning experiences.

When students are able to perceive their math personalized learning software as a part of their classroom learning experiences, they may, in turn, perceive math software and math more positively.

Future Directions

Given the rapid shift toward virtual learning as a result of the COVID-19 pandemic, we plan to refine our measure of classroom technology integration going forward. Because many aspects of this construct rely on interactions among students and educators (e.g., "I use (software) to work with other students on math."), we will need to revisit what it means for technology to be integrated into the classroom in future iterations of this survey.

In our future work, we also plan to explore how educators can better differentiate their support for math learners based on gender, grade level, and math course taking. Given our finding that software use outside of math class varies across these student characteristics, it is particularly important for educators to identify ways to encourage the use of software for those groups who are less likely to use it frequently outside of the classroom. Our survey findings suggest that additional support for male students, elementary students, and those who are not taking honors courses may be a helpful strategy. Future work may focus on how teachers engage with these particular groups of students. This investigation would be further strengthened if student and teacher survey data could be linked together so as to allow for comparison of students' and teachers' perceptions of the support that teachers provide students (Li, 2007).

Education research is complex; it is often challenging to isolate and attribute particular interventions and strategies to student outcomes. The relationships we have identified in this report are strictly correlational. Although we cannot, with any certainly, claim that the use of math software *caused* students to have more positive attitudes and perceptions, our results do suggest positive relationships among frequent software use, strong integration of technology into the classroom, and more positive attitudes and perceptions among students. Future evaluation of students' use of math software might be strengthened by administering a survey at both the beginning of the school year and the end of the school year. In doing so, we may be able to more accurate attribute changes in students' attitudes toward math to the use of math personalized learning software.

Finally, if possible, we recommend exploring the possibility of linking students' attitudes and perceptions with their math learning outcomes. While we do not dispute the importance of students having positive experiences with their math software programs, the question of whether or not those positive experiences are associated with greater learning gains still remains.

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