Key Findings

- Utah students were more likely to report that math learning software had value at lower grade levels, when they used the software frequently, and when they perceived high levels of support from educators or caregivers and high levels of alignment with classroom instruction.
- Utah students who used math learning software at high levels reported greater confidence in math, perceived more improvement in math, and were less likely to believe that math ability was fixed and unchangeable than students who did not use math software.

Background

Students in the United States are not faring well in mathematics (National Science Board (NSB), 2021). Although mathematics scores on the National Assessment of Educational Progress (NAEP) improved among both 4th graders and 8th graders from 1990 to 2007, scores were stagnant from 2007 to 2019 and plummeted in the wake of the Covid-19 pandemic (NSB, 2021). For fourth graders, 2022 NAEP scores in mathematics were lower than all previous assessments since 2005. For eighth graders, 2022 scores were lower than all previous assessments since 2003 (U.S. Department of Education et al., 2022). Consistent with these national trends, a report released by the Utah State Board of Education (USBE) in October 2021 suggests that pandemic-related learning disruptions were associated with substantial learning loss in Utah (USBE and the National Center for the Improvement of Educational Assessment, Inc., 2021). In 2022, only 44.5% of Utah's students were proficient in mathematics. This is below baseline rates of proficiency (49.7% in 2016) and below the USBE strategic plan target of 66.5% of students proficient by 2022 (USBE, 2022).

One strategy that has been employed to address student underperformance in mathematics has been to increase the utilization of educational technology – including math learning software – to supplement mathematics instruction. Supporting this strategy, several recent meta-analyses have linked the use of educational technology to positive achievement outcomes in mathematics for K-12 students (e.g., Cheung & Slavin, 2013; Hillmayr et al., 2020). Similar results have been reported in Utah, where research conducted by the Utah Education Policy Center (UEPC) for Utah's STEM Action Center has demonstrated that students who use math learning software provided through STEM Action Center's K-12 Math Personalized Learning Software Grant program[i] are more likely to be proficient in and to demonstrate growth in math than non-users, especially when usage levels are relatively high (e.g., Altermatt et al., 2022; Su et al., 2020).

Despite the promises of educational technology for supporting student learning when paired with strong face-to-face instruction, much remains to be learned about the conditions under which students find math learning software valuable or the degree to which software use is associated with positive student attitudes toward math. More work in these areas is needed, given decades of research demonstrating that students are more likely to complete activities that they find valuable (e.g., enjoyable and useful; Eccles, 1983), that students who hold a "growth mindset" (i.e., a belief that mathematics ability is not fixed but can be developed through effort) perform better in mathematics than students who hold a "fixed mindset" (e.g., Blackwell et al., 2007), and that student confidence and interest in mathematics are strong predictors of math performance, even after controlling for other factors like IQ, working memory, anxiety, and general attitudes toward academics (e.g., Chen et al., 2018).

In Fall 2023, the Utah Education Policy Center (UEPC) partnered with the USBE and Utah's STEM Action Center to contribute to the evidence base on best practices for creating "blended learning" environments that combine strong face-to-face instruction with existing and emerging educational technologies. The UEPC will be releasing its findings in a series of research briefs.

The current brief focuses on two key research questions: 1. What factors impact Utah's students' perceptions of the value of math learning software? 2. Is the use of math learning software associated with positive mathematics attitudes for students in Utah?

General Methods

In Spring 2023, 11,849 Utah students in 3rd – 12th grade completed a survey developed by the Utah Education Policy Center (UEPC). The survey was designed to assess students' use and perceptions of math p learning software and students' attitudes toward math.[ii] Eighty-nine percent (89%) of respondents to the student survey indicated that they used math learning software at school or at home during the 2022-2023 academic year. Of these, 75% indicated that they used software at high levels (i.e., a few times per week or more), 13% indicated that they used software at low levels (i.e., once per week or less), and 11% indicated that they did not use software.

Among software users, the most frequently used software programs were i-Ready (used by 35% of respondents) and ALEKS (used by 31% of respondents). Among students who reported using software, a greater percentage reported using software at high levels (i.e., a few times per week or more) at school (83%) than at home (24%).

Research Question 1. What factors impact Utah's students' perceptions of the value of math learning software?

Methods

Students who indicated that they used math learning software at school or at home during the 2022-2023 academic year were asked to indicate the degree to which they perceived the software to be valuable for their learning by rating their level of agreement with six items (e.g., "ALEKS helps me improve my skills in math"; $\alpha = .89$) on a scale from 1 ("strongly disagree") to 5 ("strongly agree"). Students were asked to use the same scale to respond to two items tapping the degree to which they felt they had the support they needed at school or at home to use the software (e.g., "If I have trouble using math software at home, I have someone who can help me") and one item tapping the degree to which they felt that the work they did on the math software was aligned with the work they were doing in class ("The work I do in i-Ready is related to the work we are doing in math class."). Student respondents were also asked to indicate their grade level and their frequency of software use at school or at home (from "never" to "daily").

Analyses

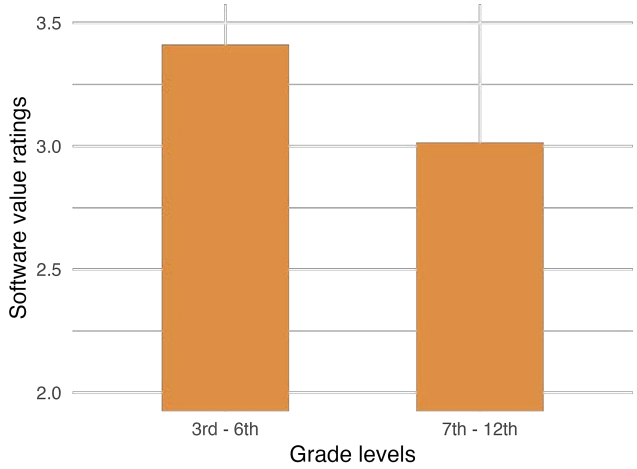
Regression analyses were used to predict students' ratings of the value of software from student grade levels, ratings of support, ratings of alignment, and frequency of software use. For these analyses, students' ratings of support and alignment were dichotomized such that high support and high alignment were operationalized as scores above the median score of "4" (i.e., "agree") on a five-point scale and high frequency of software use was operationalized as use of software at home or at school "a few times per week" or more.

Findings

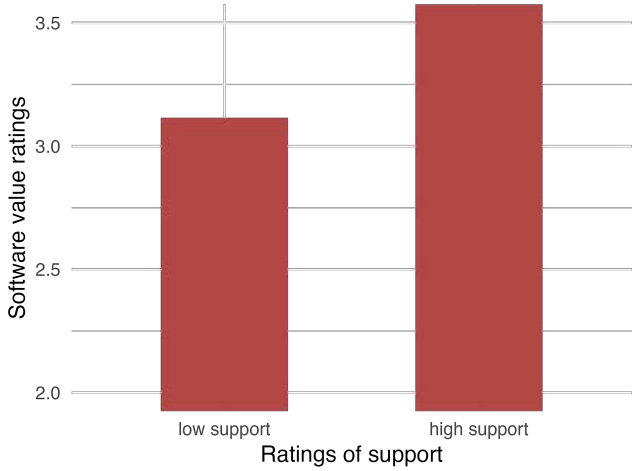
Student survey respondents reported that they found math learning software to be moderately valuable (overall mean = 3.26 on a 5-point scale). Regression analyses revealed, however, that there were statistically significant differences in students' perceptions of value across grade level, level of perceived support, level of alignment with other elements of classroom instruction, and frequency of use, all *p*s < .05. As shown in Figure 1, students were more likely to report that learning software had value at lower grade levels and when ratings of support from educators or caregivers, alignment with classroom instruction, and frequency of software use were all high. Notably, among software users, the frequency with which students reported using software in class was a stronger predictor of students' software value ratings than the frequency with which students reported using software at home.

Figure 1. Estimated marginal means from regression analyses predicting students' ratings of the value of math software from grade levels, ratings of support, ratings of alignment, and frequency of software use

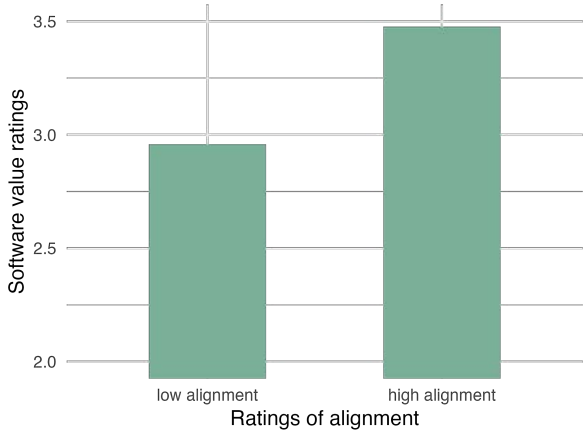
1a. Value ratings by grade levels



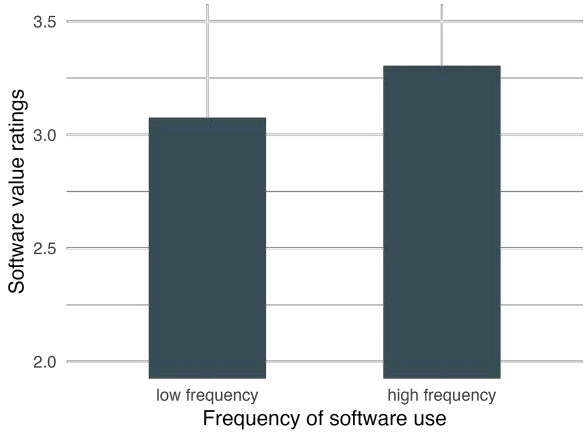
1b. Value ratings by level of perceived support



1c. Value ratings by perceived alignment



1d. Value ratings by frequency of software use



Utah students were more likely to report that math learning software had value at lower grade levels and when support from educators or caregivers, alignment with classroom instruction, and frequency of software use were all high, *p*s < .05.

Research Question 2. Is the use of math learning software associated with positive mathematics attitudes for students in Utah?

Methods

All student respondents were asked to rate their level of agreement with a series of items designed to assess their attitudes toward mathematics on scales ranging from 1 ("strongly disagree") to 5 ("strongly agree"). Three items tapped students' confidence in math (e.g., "I am good at math"; $\alpha = .86$), three items tapped students' interest in math (e.g., "When I am older, I might choose a job that uses math"; $\alpha = .80$), two items tapped students' perceptions of improvement in math (e.g., "My skills in math have improved this year"; $\alpha = .83$), and one item tapped students' endorsement of a fixed mindset ("I have a certain amount of ability in math, and I can't do much to change it."). Student respondents were also asked to indicate their grade level and their frequency of software use at school or at home (from "never" to "daily").

Analyses

Regression analyses were used to predict students' attitudes toward mathematics from average weekly software use. For these analyses, frequency of software use was treated as a categorical variable: none, low frequency (i.e., once per week or less), or high frequency (i.e., a few times per week or more). Analyses controlled for student grade level as initial analyses indicated that student grade level predicted both students' attitudes toward mathematics and level of use of math learning software.

Findings

Students were more likely to agree than to disagree that they were confident in their mathematics skills (overall mean = 3.70 on a 5-point scale), that they were interested in mathematics (mean = 3.10), and that their skills in mathematics had improved over the academic year (mean = 3.85). In contrast, students were more likely to disagree than agree that their mathematics skills were fixed (mean = 2.72).

Regression analyses revealed, however, that there were statistically significant differences in students' confidence ratings, improvement ratings, and fixed mindset ratings by frequency of software use. First, as shown in Figure 2, students who used software with both high frequency and low frequency reported greater confidence in math than students who did not use math software, *p*s < .001. Students who used software with high frequency also reported greater confidence in math than students who used software with low frequency, $p < .05$. Second, students who used software with high frequency reported more improvement in math than students who used the software with low frequency or not at all, *p*s < .0011. Finally, students who used math software with high frequency were less likely to endorse fixed mindsets than students who did not use math software, $p < .01$. In contrast, there were no statistically significant differences in students' ratings of interest by frequency of software use.

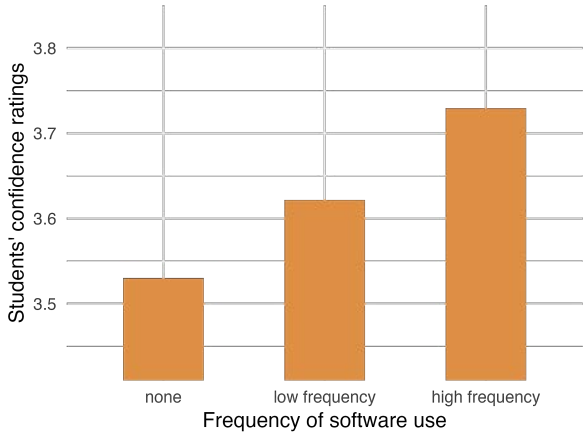
Conclusions, Caveats, and Next Steps

The current study indicates that Utah students were more likely to report that math learning software had value at lower grade levels, when they used the software frequently, and when they perceived high levels of support from educators or caregivers and high levels of alignment with classroom instruction. The current study also indicates that students who used math learning software – particularly at high levels – had more positive attitudes toward math than students who did not

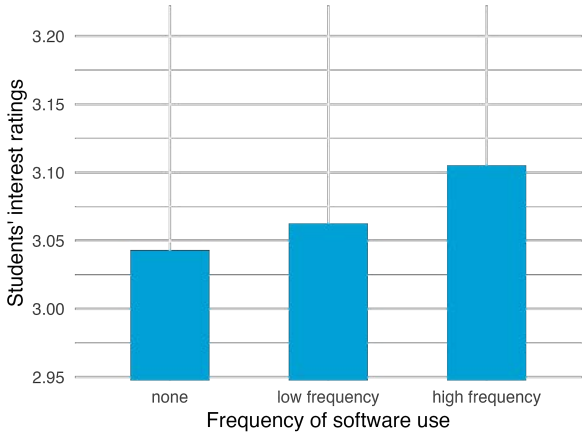
use math software. Specifically, students who used math software at high levels during the 2022-2023 academic year reported more confidence in their math skills, were more likely to believe that their math skills had improved over the academic year, and were less likely to believe that their ability in mathematics was fixed and unchangeable than students who did not use software.

Figure 2. Estimated marginal means from regression analyses predicting students' confidence, interest, improvement, and fixed mindset ratings from students' frequency of software use

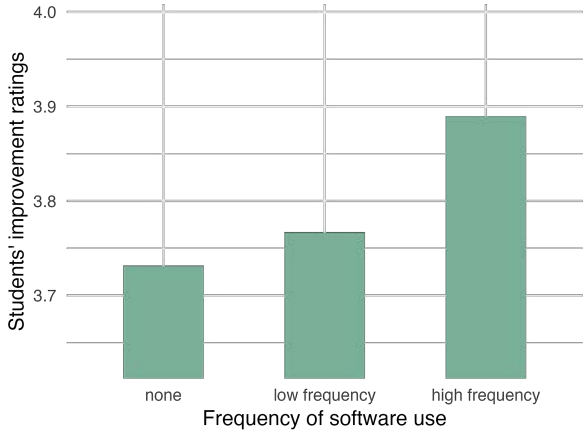
2a. Confidence ratings by level of software use



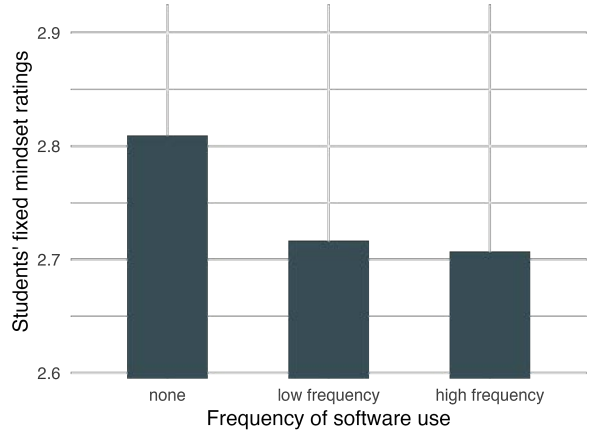
2b. Interest Ratings by level of software use



2c. Improvement ratings by level of software use



2d. Fixed mindset ratings by level of software use



Utah students who used math learning software at high levels reported greater confidence in math, perceived more improvement in math, and were less likely to believe that math ability was fixed and unchangeable than students who did not use math software, all *p*s < .05.

These findings are important given decades of research showing that attitudes toward math can be a strong predictor of math achievement, including one recent study that indicates that growth mindsets can serve as a buffer against the deleterious effects of poverty. In a nationwide sample of high school students from Chile, students in the lowest 10th percentile of family income who exhibited a growth mindset showed academic performance as high as that of students in the 80th percentile of family income who exhibited a fixed mindset (Claro et al., 2016).

The results of the current study are promising, but they should be interpreted with caution. Although we were able to control for student grade level in our analyses of associations between software use and attitudes toward math, we were not able to control for other potentially important third variables. One potentially important third variable is student low-income status. In a recent report released by the UEPC (Altermatt et al., 2022), we found that student low-income status was related to both levels of software use and student achievement. Given these findings, it is possible that the observed relationship between the frequency of software use and students' attitudes toward math can be partially (or wholly) explained by the impact of students' low-income status on software use and attitudes toward mathematics. We were also unable to examine the directionality of the relationship between the frequency with which students used math learning software and their attitudes toward math in the current study. Although it is possible that software use causes improved attitudes toward math, it is also possible that positive attitudes toward math cause students to use math software more frequently.

Beginning in Fall 2023, the UEPC will join student survey data with teacher survey data, student achievement data, and student software usage data to explore which software implementation practices (e.g., the degree to which teachers set time-based vs. mastery-based goals for students) are most closely associated with strong student achievement outcomes in mathematics. An important component of these analyses will be examining factors that moderate associations between implementation strategies and student achievement outcomes, including teacher characteristics (e.g., # of years of teaching), school characteristics (e.g., percent of low-income students), and student characteristics (e.g., time spent using math learning software).

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[i] https://stem.utah.gov/educators/funding/k-12-math-personalized-learning-software-grant/

[ii] A full report on survey results can be found on the Utah Education Policy Center website. Importantly, the sample of teacher respondents was similar to the population of K-6 teachers and 7-12 grade math teachers in Utah who were invited to participate in the survey.