Explorelearning®

Technical Research Report

THE USAGE OF GIZMOS AS A TOOL FOR DEVELOPING NGSS SCIENCE PRACTICES

AN ESSA TIER 3 STUDY OF THE EFFECTIVENESS OF GIZMOS FOR STUDENT SCIENCE ACHIEVEMENT

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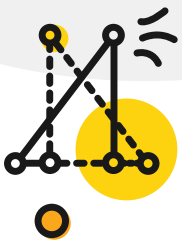

EXECUTIVE SUMMARY

The current study looked at whether the usage of Gizmos helps students develop proficiency in the skills that are evaluated in Next Generation Science Standards (NGSS) aligned assessments. Data was drawn from a sample of over 21,000 11th-grade students across 93 urban public high schools in California. Gizmos usage rates over the 2022-2023 school year were compared to the results of the California Science Test (CAST), an NGSS-aligned state science assessment, administered in Spring 2022 and Spring 2023. The study used a correlational methodology, including statistical controls for potential selection bias. The results show that increased usage of Gizmos was significantly related to improved student achievement; schools with higher usage of Gizmos had significantly more students meeting or exceeding science achievement standards compared to schools with lower usage.

Specifically, the key findings include:

- **Students at schools with higher Gizmos usage were 1.3 times more likely to meet or exceed standards on the science assessment than students at schools with lower Gizmos usage.**
- **This difference was found to be statistically significant, even when controlling for the impact of potentially mediating variables such as SES and student-teacher ratio.**
- **A dosage response was also found; greater Gizmos usage was significantly related to higher proportions of students meeting or exceeding standards.**
- **There was no similar relationship found between prior year scores and current Gizmos usage, providing additional support for the hypothesis that Gizmos usage provides students with the relevant practice needed to improve performance on an NGSS-aligned standardized assessment.**

Overall, the current study found that ExploreLearning Gizmos usage was related to significantly higher science achievement as measured by an NGSS state-wide assessment, even when controlling for variables typically associated with statistical sample bias, with exploratory analyses further supporting a causal hypothesis. **This evidence supports the usage of Gizmos as an effective and efficient program that can be used with all levels of learners. Gizmos can help teachers provide the learning experiences needed to support the achievement of proficiency standards on state science assessments.**

This efficacy study was designed to meet the Every Student Success Act (ESSA) Tier 3 (Promising) level of evidence.

INTRODUCTION

ExploreLearning is a recognized leader in the educational software market, creating high-quality solutions for the most challenging problems in K-12 math and science learning. ExploreLearning ***Gizmos*** online simulations bring the power of inquiry-based learning to teachers and students in grades 3–12. *Gizmos* help teachers take advantage of research-proven instructional strategies and enable students of all ability levels to develop conceptual understanding in math and science. With a library of more than 550 academic learning standards-aligned *Gizmos*, teachers can supplement and enhance students' blended learning experiences with interactive visualizations of math and science concepts that are tough to teach and tough to understand.

Each *Gizmo* focuses on a related set of skills or concepts, with multiple lesson activities at varied levels of complexity and depth of content to support scaffolding. In each Gizmos simulation, students can manipulate key variables, generate and test hypotheses, and engage in extensive "what-if" investigations. Students participate in interactive experiments as they explore the concepts behind the phenomena, ultimately coming to understand the deeper underlying concept of a topic and applying it to solving new scenarios and problems.

Additionally, *Gizmos* supports all three dimensions of the Next Generation Science Standards for K–12 Science Education: disciplinary core ideas, crosscutting concepts, and science and engineering practices. These research-based standards were developed to improve science education for all students and set the expectations for what students should know and be able to do. These standards call for students to think and work like scientists and engineers — asking questions and learning through investigation and discovery. Since the release of these standards in 2013, at least 20 U.S. states have fully adopted NGSS standards, and many more have created their own standards using the related NRC framework. Many of these states have also adopted NGSS-aligned assessments which integrate all three dimensions of the standards, to assess both knowledge and skills. ***If students have never engaged in the kinds of practices found in Gizmos, such as developing and using models, they will be underprepared for NGSS-aligned assessments.***

Gizmos inquiry-based approach to learning has been validated by extensive research as a highly effective way to build conceptual understanding in math and science (Cholmsky, 2003). Several independent studies by university-affiliated researchers over the past 15 years have demonstrated the efficacy of Gizmos, with significant positive impacts from Gizmos use in the classroom found on a range of important outcomes including student achievement, classroom engagement, content knowledge, and knowledge application in both math and science (see ExploreLearning, 2023 for a research summary). However, many of these previous studies take a controlled, experimental approach to measuring efficacy, with small

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[1]For additional information on all the ExploreLearning products, please visit https://explorelearning.com/

sample sizes and controlled and contrived learning experiences. ***The current study takes an applied and school-level approach to determine whether the adoption and usage of Gizmos across a school is related to higher student achievement***. The results of the current study help to validate the efficacy of Gizmos in a real-world setting, where adoption and implementation are less controlled and structured, and more impacted by external and environmental factors. The current findings can help administrators and teachers understand the potential of educational technology to serve as a tool for providing students with relevant experiences and practice needed to succeed on skills-based, NGSS-aligned assessments

The current report details the findings from an efficacy analysis of *Gizmos* as a digital complement to the existing science curriculum across nearly 100 urban high schools in California. The goal of the study was to associate Gizmos usage with student achievement in meeting or exceeding grade-level science proficiency standards. The current study does not include an assessment of usage fidelity (i.e. whether teachers are using the program in line with recommended best practices) but looks at how widely across a school the program has been adopted. We also take an exploratory look at other usage metrics, including the extent of product usage across a variety of standards/courses and the frequency of usage by students. The outcome measure being explored is student scores on the California Science Test (CAST), an NGSS-aligned state science achievement test. Here we specifically focus on high school testing, which captures the accumulated effect for these students of usage of Gizmos across both middle and high school years.

This study was designed to meet Every Student Succeeds Act (ESSA) Tier 3 (Promising) levels of evidence according to the U.S. Department of Education guidelines. The study uses a correlational design to look at the statistically significant relationships between the independent variable (Gizmos usage) and the dependent variable (science proficiency), with statistical controls included to account for potential selection bias.

METHODOLOGY

Study Sample

The data for this study came from 93 majority-minority, urban high schools in California, which includes a total testing data of over 21,000 students. Demographic information about the students enrolled in each school was obtained from the NCES Common Core of Data (https://nces.ed.gov/) as well as the state data dashboard. Information presented in this study included student-to-teacher ratio, student racial and ethnic demographics, and a school-level indicator of family socio-economic status.

During the 22-23 school year, secondary science teachers at all 93 schools had access to the Gizmos program. Several schools had access to Gizmos as early as 2015, with all schools gaining access by fall 2021. Professional Development and support were offered to the teachers through the Customer Success team.

Independent Variable: Gizmos usage

Gizmos usage data was aggregated at the school level. **Table 2** describes the three variables calculated and used in the current study. The primary variable for assessing how widely used Gizmos were across a school was calculated by dividing the number of students who accessed Gizmos at least once during the 22-23 academic year by the total number of enrolled students at that school. A median split was also used to group schools into high users (n = 46 schools) and low users (n = 47 schools). **Table 3** includes descriptive information about the high and low using Gizmos schools. Two additional variables were calculated for exploratory analyses looking at usage patterns and standards achievement. The number of distinct Gizmos used by a school provides a measure of how widely used Gizmos are across a school; schools using more distinct Gizmos are likely to incorporate Gizmos across a greater variety of lessons and courses. The third variable, the average number of Gizmos views per student per school, give us insight into the frequency of use among those students who were using Gizmos. These three variables are distinct measures of adoption, which may or may not align with intended pedagogical approaches, but together can give us a high-level view of a school's usage patterns.

Table 2: Gizmos usage variables calculated for the current study

Variable	Calculation	Insights
Proportion of students using Gizmos	The percentage of all enrolled students at the school who accessed Gizmos at least once during the 22-23 academic year	Assess the degree to which a school fully adopts the program for all students; Used to differentiate high vs low using schools
Distinct Gizmos used	The number of distinct Gizmos used by at least one student across the school during the 22-23 academic year	Assess the breadth of Gizmos adoption across different classes, standards, and/or units
Gizmos views per student	The total number of Gizmos views for the entire school divided by the number of students at that school who accessed Gizmos at least once during the 22-23 academic year	A measure of the frequency of usage by active students

Table 3: Descriptive information about schools with high Gizmos usage and schools with low Gizmos usage

	Proportion of students using Gizmos	Gizmos views per student M(SD)	Distinct Gizmos used M(SD)	Student Demographics	Percentage of schools categorized as high-poverty	Student-Teacher Ratio
Low using schools (n = 47)	Mean = 14% Range = 1% - 26.5%	4.31 (2.21)	10.66 (9.74)	80% Hispanic 7% White 4% Asian 8% Black	83%	19.9
High using schools (n = 46)	Mean = 43% Range = 27.4% - 80.2%	6.04 (3.91)	32.50 (29.19)	78% Hispanic 6% White 7% Asian 7% Black	78.3%	20.0

Dependent Variable: NGSS-aligned State Science Test

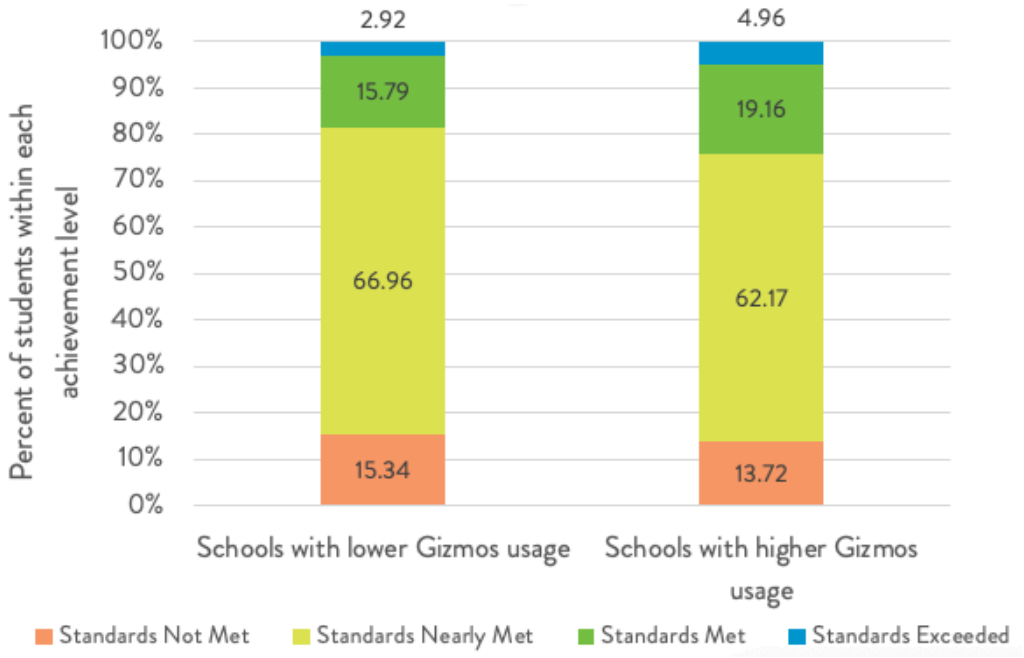
Outcome data was scores on the CAST high school assessments in spring 2023, collected from the state assessment public dashboard. The relevant metric analyzed in this study was the percentage of enrolled students who fell into the Level 3 (Standards Met) or Level 4 (Standards Exceeded) categories. According to the state website, falling into this category indicates that a student shows an understanding of and ability to apply the knowledge and skills that make up the state standards performance expectations.

Planned Analyses

All statistics were performed using SPSS v29. To satisfy promising levels of evidence for ESSA, we planned an analysis that allowed the inclusion of statistical controls for variables related to potential selection bias. One-tailed significance testing was used throughout to test the directional hypothesis that schools with higher Gizmos usage would outperform schools with lower Gizmos usage. A one-way ANCOVA was planned with SES measures and student-teacher ratio used as covariates. Correlational analyses were also planned to test for exploratory relationships between increased usage and increased performance.

RESULTS

In schools with higher Gizmos usage, 24% of students met or exceeded standards on the test, compared to only 18% of students in schools with lower Gizmos usage. A one-way ANCOVA was conducted to test the significant unique impact of Gizmos usage on meeting or exceeding test grade-level standards while statistically controlling for the impact of SES and student-teacher ratio[1]. Even when accounting for covariates, Gizmos usage remained significant [$F(1,93)=3.573$, $p = .031$]. This means that the likelihood of students achieving or exceeding grade-level standards on the 2023 exam can be partially attributed to high or low Gizmos usage during that school year.



To further support the hypothesis that Gizmos usage in 22-23 is driving student learning and improving 2023 spring scores, a similar analysis was run using 2022 exam scores. A significant relationship in this analysis would suggest that teachers with higher achieving students are simply more likely to use Gizmos and would decrease our confidence in a causal relationship of Gizmos usage on student achievement. There was no significant difference in 2022 test scores between the two groups of schools [one-sided t-test on mean scale scores, $t(1,91)=.146$, $p = .442$], providing additional confidence that the relationship between Gizmos usage and test scores reflects a causal impact of program usage.

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[1]Preliminary analyses showed that SES was highly correlated with student race/ethnicity (r's > .7), including the proportion of Asian, White, and Hispanic students. To avoid violating the assumptions for ANCOVA, we focused on SES as the most relevant predictor and included only that variable in the current analysis.

We also looked at more exploratory relationships between usage patterns and test scores. Pearson's correlations found significant, positive correlations between the percentage of students meeting or exceeding standards at a school and the number of distinct Gizmos used by that school [$r(93) = .307$, $p = .002$] and the average number of views of Gizmos per student [$r(93) = .190$, $p = .034$]. This provides preliminary evidence that different usage and dosage patterns, specifically a greater breadth and depth of usage of Gizmos, are related to test scores, further supporting the hypothesis that Gizmos usage supports science achievement.

CONCLUSIONS

The current study used a correlational method to test the hypothesis that Gizmos usage supports student proficiency on a Next Generation Science Standards (NGSS) aligned state assessment. The NGSS standards call for students to think and work like scientists and engineers — asking questions and learning through investigation and discovery. If students have never engaged in the kinds of practices found in Gizmos and STEM Cases, such as developing and using models, they will be underprepared for these assessments.

Our results showed that across nearly 100 urban high schools in California, students at schools with higher usage of the Gizmos product were more likely to meet or exceed proficiency standards on the state Science Test compared to students at schools with lower usage of Gizmos. This relationship was significant even when controlling for variables typically associated with student achievement, including socioeconomic status and student-teacher ratio. Additional analyses further support our causal hypothesis, including directionality over time and a significant dosage response. These results, with statistical controls for selection bias, meet Promising ESSA Evidence (Tier 3).

The current findings should provide increased confidence to administrators and teachers that Gizmos can be implemented as a tool for providing students with relevant experiences and practice needed to succeed on skills-based, NGSS-aligned assessments.

ABOUT EXPLORELEARNING

ExploreLearning LLC, based in Charlottesville, VA, was founded in 1999 by educators looking for new ways to inspire students across grades K–12 and help them succeed in math and science. With a philosophy of life-long learning driving our thought leadership, a careful attention to the current needs of educators in today's rapidly-shifting educational culture, and a legacy of proven results, ExploreLearning is the best combination of proven expertise and innovative solutions over time to meet today's and tomorrow's educational challenges.

Our four digital programs (Reflex®, Frax®, Science4Us®, and Gizmos®) are currently used in classrooms in every state in the U.S. and more than 80 countries worldwide. Our programs are state- and national-standards aligned, including Next Generation Science Standards (NGSS) and the Standards for Mathematical Practice (SMP). ExploreLearning is a recognized leader in the educational software market, earning many major edtech awards.

We aim to foster student success through the use of galvanizing, age-appropriate multimedia, including interactive simulations, STEM case studies, adaptive games, instructional videos, and much more. Our development team of engineers, researchers, and instructional-design experts, most of whom are former educators, are continually innovating beyond the latest advancements in instructional pedagogy and edtech. Our programs support students in developing mastery of fundamental skills and deep conceptual understanding in math and science, while also fully engaging them in the process of internalized learning, promoting growth mindset, resiliency, productive struggle, and perseverance.

Our goal is to provide educators with captivating, best-in-class digital learning in math and science that helps students reach their full potential. We firmly believe that teachers are mission-critical, i.e., the greatest influence on student success. We also believe that data, instruction, and practice, when operating in tandem, are paramount to improving student learning and academic achievement. In support of these foundational beliefs, we deliver curricula, professional learning, and implementation and technical support services that:

- Combine research-proven instructional methods and innovative technology
- Enable equitable access to math and science learning for all students
- Build strong, lasting foundations for student success by developing procedural and conceptual understanding
- Supplement core curricula with flexible digital and blended implementation
- Create positive outcomes and results for both students and teachers

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