The Impact of Computational Thinking on Louisiana Students' STEM Outcomes

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About Education Northwest

Education Northwest is a nonprofit, nonpartisan organization dedicated to helping all children and youth reach their full potential. We partner with public, private, and community-based organizations across the country to improve student success. While most of our work centers on the Pacific Northwest, our evaluations, technical assistance, and research studies have national impact and provide timely and actionable results.

This report presents findings from Education Northwest's evaluation of Louisiana State University's federal Education Innovation and Research (EIR) early-phase grant (U411C190287) called "A modern approach to the integration of programming and mathematics."

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Abstract

Computational thinking encompasses proficiencies in computer science and general problem-solving and can support students' learning across subject areas and success in science, technology, engineering, and mathematics (STEM) education and career pathways. To support students' STEM outcomes, many school districts are offering computer science education. Louisiana State University (LSU) received a federal Education Innovation and Research (EIR) grant (U411C190287) to develop and implement an Introduction to Computational Thinking (ICT) course. From fall 2020 through spring 2024, Education Northwest evaluated the implementation and impact of the ICT course. The impact study included high schools across East Baton Rouge Parish School System and urban and rural communities in Louisiana that serve large populations of students from economically disadvantaged backgrounds and students of color. Using a quasi-experimental design, this study found a positive impact of the ICT course on students' high school math achievement, including Algebra I state assessment scores and earning credit in an Algebra II or higher math course. The study recommends further scaling and evaluation of this computer science innovation to promote STEM outcomes for historically underserved students across the country.

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Background

Computational thinking skills include programming, coding, and foundational problem-solving skills (Montuori et al., 2023). Through computational thinking, learners gain the ability to apply the skills required of computing and computer science to solve everyday problems (Montuori et al., 2023). Since computational thinking encompasses proficiencies in computer science and general problem-solving, it is important not only for preparing students in the field of computer science but also, more broadly, for supporting learning in areas beyond computer science (Montuori et al., 2023; Ye et al., 2022). Computer science education in high school has been found to have positive effects on grades in other science courses (Bruno & Polikoff, 2023) and long-term bachelor's degree attainment, employment, and earnings (Liu et al., 2024).

While the benefits of computational thinking and computer science education are increasingly understood, challenges with implementing it broadly in public schools include a shortage of adequately trained computer science teachers and unequal access to computer science courses (Code.org et al., 2024). Further, the rapid expansion of computer science education experienced a slowdown during the COVID-19 pandemic.

Louisiana State University (LSU) received a federal Education Innovation and Research (EIR) early phase grant to develop and implement an Introduction to Computational Thinking (ICT) course. ICT is a yearlong course for Algebra I-ready students. The course focuses on developing students' problem-solving, programming, and mathematics skills and is designed to improve performance on Louisiana state math assessments, particularly the Algebra I state assessment. The ICT intervention also includes an intensive program to train teachers in how to instruct and assess students in computer science programming. Participating teachers are not required to have any experience with computer science or programming.

In pursuit of equity in computer science education, ICT is intentionally offered to schools with large percentages of students from low-income families and students of color. Through the EIR grant, the ICT course was implemented in high schools in East Baton Rouge Parish School System, rural schools in Louisiana, and a small number of charter schools in New Orleans, and a research team at Education Northwest evaluated the implementation and impact of ICT from fall 2020 through spring 2024.

Impact Study Description

Research Questions

ICT is a yearlong course taken in grade 9 or grade 10 concurrently with Algebra I. It is also a required course in three of the four LSU STEM Pathways: Computing, Pre-Engineering, and Biomedical Sciences. The LSU STEM Pathways are designed to increase the number of Louisiana students who take high-quality and engaging STEM courses.

The ICT course uses a high-level functional language to maximize transfer, an application programming interface (CodeWorld), and project-based instruction that integrates learning objectives for math and coding and addresses basic mathematical content in algebra and geometry. Following the principles of the What Works Clearinghouse (WWC)-reviewed Core-Plus mathematics curriculum (U.S. Department of Education, 2010), the ICT curriculum has the following features:

- Contains interwoven strands of content from algebra, geometry, probability, and discrete mathematics
- Has a strong emphasis on modeling
- Uses technology to promote reasoning with multiple representations (verbal, numerical, graphical, and symbolic)
- Focuses on goals in which problem solving based on mathematical thinking (and in this case, also computational thinking) is central
- Emphasizes active learning, small-group collaboration, and summarizing activities that lead to reflection on the main ideas

Furthermore, it was designed under the following assumptions:

- Students taking the course will have a wide spectrum of interests
- Most students who take the course are not going to become programmers
- Most teachers who teach the course will have no computer science background
- Despite the above, the course must have rigorous content
- Students will demonstrate their learning by creating computer programs
- Creativity and choice within the given constraints is an essential aspect

Based on these features and assumptions, the evaluation used a quasi-experimental design to match students within schools and examine the immediate impact of ICT on mathematics achievement on the Algebra I state test (a compulsory subject to graduate) and the impact of ICT in later high school years on geometry achievement (another compulsory subject to graduate), mathematics achievement in Algebra II or higher (which is required for students attending university following graduation), and college-level math and computer science coursework (i.e., dual enrollment and Advanced Placement [AP]). There were four confirmatory research questions for the study:

1. What is the effect of enrolling in ICT on students' end-of-year **algebra achievement** compared to the end-of-year algebra achievement for students who did not enroll in ICT?
2. What is the effect of enrolling in ICT on students' **geometry achievement** in later school years compared to the geometry achievement in later school years for students who did not enroll in ICT?
3. What is the effect of enrolling in ICT on students' likelihood of **earning high school credit in Algebra II or higher math courses** in later school years, compared to the likelihood of earning credit in Algebra II or higher math courses in later school years for students who did not enroll in ICT?
4. What is the effect of enrolling in ICT on students' likelihood of **earning high school credit in college-level math and computer science courses** in later school years, compared to the likelihood of earning credit in college-level math and computer science courses in later school years for students who did not enroll in ICT?

Intervention Description

The ICT intervention has four key components: the ICT teacher training, ICT online portal and curriculum, ICT teacher recruitment and student enrollment, and a train-the-trainer session to promote intervention sustainability. A logic model for the intervention is included in appendix A, and a description of the intervention during the study period is below.

1. **ICT teacher training.** To be prepared to teach ICT courses, teachers must participate in a multi-faceted professional development program that includes four components.
    - Teachers participate in a **24-day summer training** that prepares them to support students' completion of the ICT curriculum. (Beginning in summer 2023, the summer training was changed to a 12-day training course.) The training is offered in early summer and introduces teachers to fundamental computing principles rather than a specific programming language. Teachers engage with theme-based units of curriculum that emphasize the transfer of computing principles to mathematics and use project-based learning to create specific computing products. Units are divided into lessons, each comprising several exercises and a longer activity that requires students to write code that demonstrates mastery of the skill covered in the lesson. During the training, teachers must first complete the work as students would before they gain access to the teacher-facing materials (including four units of curriculum, teaching solutions, and pacing guides). Teachers must pass the student ICT course with a score of 80 percent before they are considered certified to teach ICT and gain access to the ICT materials for their classroom.
    - After the initial training and while they are teaching the course, teachers attend monthly **community of practice sessions.** During the school year, ICT teachers participate in seven to eight virtual community of practice sessions, each 1.5 to 2 hours, led by the ICT developers.

These sessions are open to all ICT teachers, regardless of when they took the training and were certified, but only those teachers who participated in the more recent summer training are required to attend. The sessions incorporate virtual documents, class sessions, and rubrics and cover content such as best pedagogical practices, feedback on grading, student recruitment, and a review of content areas that have proven challenging for students to learn and/or teachers to teach (based on data from previous years). In addition to the planned content, teachers can ask questions, receive targeted support, and share successes. Teachers are compensated for their time to participate in the community of practice for up to one year following the training. After the first year, teachers can continue to participate, but they are not reimbursed for their time. Additional one-on-one coaching is provided to teachers, as needed, and includes a prescriptive plan for the teacher and scheduled times for checking in.

- The **online community of practice** is initiated during the 24-day training, and teachers continue to have access to it for as long as they teach the ICT course. The ICT developers moderate the online community of practice and expect teachers to communicate regularly with them and with each other at least once a month. Teachers can use the online community of practice to ask questions and address challenges they encounter while teaching the curriculum. For technical questions, ICT developers respond within 24 hours to ensure teachers have the information and support they need to continue teaching.
- Finally, teachers attend an annual **refresher training.** This training addresses the critical components of the course that teachers and/or students struggled with the previous year as well as any changes the ICT developers made to the course in response to these challenges. It is a half-day event held virtually in July or August. All teachers providing ICT instruction for the upcoming school year are required to attend the refresher training.

These four components of the teacher training help teachers develop the requisite programming, computational thinking, and pedagogical skills to engage and support students in the ICT coursework. Once teachers have completed the training and are certified to teach ICT, their school can offer the course, and they can teach it.

2. **ICT online portal and curriculum.** All components of the ICT course are online. This includes portals for teachers and students. The teacher portal provides access to the teaching materials/manual (inclusive of four units, teacher solutions, pacing guide); grading exercises; and the online community of practice. The student portal includes four units with student activities.
3. **ICT teacher recruitment and student enrollment.** Administrators recruit teachers to attend the ICT training and teach the course. To increase the diversity of the STEM teacher workforce, ICT is designed so that any teacher—not only computer science teachers—can provide instruction once trained and certified. In terms of student enrollment, LSU set a goal that at least 21 percent of each participating school's grade 9 student population be enrolled in the course. As ICT believes in computer science for all, the student enrollment in ICT should mirror the grade 9 student enrollment

in terms of gender, race and ethnicity, and federal program participation (e.g., free or reduced-price lunch eligibility, special education, migrant education, English learner services).

4. **Train-the-trainer instruction.** To support the sustainability and scaling of the intervention, there is a train-the-trainer session for teachers who have taught the ICT course and want to help train new teachers. The full-day training takes place each spring and includes six modules that address content including the philosophy behind the course; what the course is and is not; teacher encouragement and support; and assessing and supporting teacher knowledge gaps. Educators participating in the train-the-trainer session will increase their skill in adult and online pedagogy. As they complete the training, provide instruction, and support new teachers, the number of schools offering and teachers teaching the ICT course will increase, ultimately leading to a trained, diverse, and competent STEM workforce.

IMPLEMENTATION FIDELITY

The external evaluation studied two years of intervention implementation (2021–22 and 2022–23) and found that certain components of the intervention were implemented with a greater degree of fidelity than others.

Fidelity of implementation was measured separately for each of the four program intervention components, and each component was defined by multiple indicators assessed at the teacher, school, or program-level. The evaluation team worked with LSU to define the thresholds for adequate fidelity for each indicator and determine how to roll up implementation scores and measure adequate fidelity at the component level. The threshold established a binary score, based on an analysis of implementation data, of whether the indicator was implemented with adequate fidelity (i.e., as intended) in a particular year.

At the component level, in both years of the implementation study, two of the four components were implemented with low fidelity—ICT teacher training and teacher recruitment and student enrollment. The expectations to reach adequate implementation fidelity of ICT teacher training were high and required that at least six of the seven program-level indicators (1, 3, 5, 7, 9, 10, and 12) had to be implemented at an adequate level, at least five of the six teacher-level indicators (2, 4, 6, 8, 11, and 13) had to be implemented at an adequate level, and indicators 1, 2, and 5 had to be implemented with adequate fidelity. However, in both years of the implementation study the intervention could not meet these fidelity standards.

Likewise, it was challenging to meet the teacher recruitment and student enrollment implementation fidelity expectations. ICT was implemented during the height of the pandemic, which had far-reaching impacts on teacher retention and student engagement and mobility. Key component 3, indicator 1 was considered implemented with adequate fidelity if 90 percent of participating schools retain or replace their ICT teacher(s). However, of the 39 teachers (across 34 schools) who taught during the 2021–22 school year, 19 teachers left and were not replaced in those schools in the 2022–23 school year, and of the 41 teachers (across 40 schools) who taught during the 2022–23 school year, 22 teachers left and were not replaced in those schools in the 2023–24 school year.[1] Key component 3, indicator 2 was considered implemented with adequate fidelity if at least 90 percent of participating schools enrolled at least 21 percent of their grade 9 student population in ICT. In both years of the implementation study, less than 90 percent of participating schools were able to meet this threshold.

On the other hand, one component (ICT online portal and curriculum) was implemented with adequate fidelity in both years of the study, while the train-the-trainer session was not implemented in 2021–22 and was implemented with adequate fidelity in 2022–23. Table 1 summarizes the implementation study findings. Complete findings are available in the full report (Roccograndi & Hodara, 2024).

Table 1. Summary of implementation fidelity study findings

Key components and indicators	Implementation level 2021–22	Implementation level 2022–23
Key component 1. ICT teacher training		
Indicator 1. LSU offers 24-day training course	Adequate	Adequate
Indicator 2. Teacher participates in 24-day training course and is certified	Adequate	Low
Indicator 3. LSU certifies teachers after 24-day training course	Adequate	Low
Indicator 4. Teacher expresses satisfaction with 24-day training course	Low	Adequate
Indicator 5. LSU offers community of practice sessions (7–8)	Adequate	Adequate
Indicator 6. Teacher participates in community of practice sessions	Adequate	Low
Indicator 7. LSU develops and offers prescriptive plan and one-on-one coaching to teachers who receive provisional certification	Adequate	Adequate
Indicator 8. Teacher with provisional certification receives a prescriptive plan and participates in its activities	Adequate	Adequate
Indicator 9. LSU provides online community of practice	Adequate	Adequate
Indicator 10. LSU provides timely technical support via online community of practice	Adequate	Low

[1] The number of schools cited here is more than the number of schools in the impact evaluation. The implementation evaluation included more schools than the impact evaluation because ICT was also implemented in suburban/low-need schools that were not a part of the impact evaluation.

Key components and indicators	Implementation level 2021–22	Implementation level 2022–23
Indicator 11. Teacher regularly engages in online community of practice	Low	Low
Indicator 12. LSU offers annual refresher training	Adequate	Adequate
Indicator 13. Teacher attends annual refresher training	Adequate	Adequate
Component-Level Implementation Fidelity Rating	***Low***	***Low***
Key component 2. ICT online portal and curriculum materials		
Indicator 1. LSU provides teacher instructional materials comprised of four units and teacher solutions	Adequate	Adequate
Indicator 2. LSU provides student learning materials comprised of four units	Adequate	Adequate
Indicator 3. Teacher expresses satisfaction with teacher instructional and student learning materials	Adequate	Adequate
Component-Level Implementation Fidelity Rating	***Adequate***	***Adequate***
Key component 3. Teacher recruitment and student enrollment		
Indicator 1. District/school staff members recruit or replace teachers	Low	Low
Indicator 2. School staff members encourage students to enroll in ICT	Low	Low
Component-Level Implementation Fidelity Rating	***Low***	***Low***
Key component 4. Train-the-trainer session		
Indicator 1. LSU offers train-the-trainer session	NA	Adequate
Indicator 2. Instructor attends train-the-trainer session	NA	Adequate
Component-Level Implementation Fidelity Rating	***NA***	***Adequate***

Note: To calculate implementation fidelity ratings, the evaluation team collected and analyzed recruitment materials; teacher training attendance records; program records regarding ICT certification; teacher surveys administered to assess overall quality and satisfaction with the training and instructional materials; the schedule for community of practice sessions; and materials in the online community of practice (to assess access, technical support, and teacher participation via posts) and teacher and student portals (to assess access and instructional material content).

Source: Education Northwest.

Study Setting

The impact study included high-need high schools, defined by the percentage of students eligible for free or reduced-price lunch, in the East Baton Rouge Parish School System and throughout both urban and rural regions of Louisiana. LSU led the recruitment of participating parishes (i.e., districts) and high schools. LSU first asked principals to nominate teachers for the ICT training before reaching out to teachers for interest in being trained to teach ICT course sections. Schools with trained and certified ICT teachers could then offer ICT. Schools entered the study in different years between 2020–21 and 2023–24, and not all schools offered ICT every year, so the study sample shifted each year.

In total there were 25 high schools across 12 school systems in the impact study (table 2), 40 percent of which were rural schools. Grade 9 enrollment varied between a low of 42 to a high of 338 students. On average, 92 percent of students were economically disadvantaged, and 77 percent were students of color.

Table 2. Description of impact study schools

School system	High school	First ICT year	School locale	Grade 9 enrollment	Percentage economically disadvantaged	Percentage students of color
East Baton Rouge	Belaire	2020–21	Midsize city	179	91	98
	Broadmoor	2020–21	Midsize city	198	87	96
	Glen Oaks	2021–22	Large suburb	112	94	99
	Helix Mentorship STEAM Academy	2023–24	Midsize city	104	87	98
	Istrouma	2021–22	Midsize city	113	94	100
	McKinley	2020–21	Midsize city	150	85	97
	Northeast	2022–23	Distant rural	54	88	91
	Scotlandville Magnet	2021–22	Midsize city	178	90	99
	Tara	2020–21	Midsize city	243	87	95
	Woodlawn	2020–21	Large suburb	338	76	86
Calcasieu	Washington/Marion Magnet	2022–23	Small city	128	90	98
East Carroll	General Trass	2022–23	Remote rural	53	97	100
Morehouse	Bastrop	2021–22	Distant town	147	90	92
Pointe Coupee	Livonia	2020–21	Distant rural	197	72	58
Saint Landry	Beau Chene	2021–22	Fringe rural	200	70	51
	Eunice	2021–22	Distant town	146	77	50
	North Central	2022–23	Remote rural	42	91	88
	Northwest	2021–22	Distant rural	95	85	79

School system	High school	First ICT year	School locale	Grade 9 enrollment	Percentage economically disadvantaged	Percentage students of color
	Port Barre	2021–22	Distant rural	69	66	21
Saint Martin	Breaux Bridge	2021–22	Fringe rural	142	83	53
Vernon	Leesville	2021–22	Remote town	161	64	52
Washington	Pine School	2020–21	Remote rural	93	64	20
West Feliciana	West Feliciana	2020–21	Distant rural	138	43	38
Einstein Charter Schools	Sarah T. Reed	2022–23	Large city	99	97	99
Type 2 charter school	New Orleans Military & Maritime Academy	2021–22	Large city	235	84	80
Sample totals and averages						
12 school systems	25 high schools		40% rural	Average = 127	Average (weighted) = 92%	Average (weighted) = 77%

Source: School locale is from the National Center for Education Statistics (Locale Lookup). Grade 9 enrollment, percentage economically disadvantaged (i.e., eligible for free or reduced-price lunch), and percentage students of color are from Louisiana Department of Education 2024–25 public enrollment data (Enrollment Data).

Study Participants

Students in the treatment group were students in impact study schools who enrolled in ICT concurrently with Algebra I and thus were taking the Algebra I state assessment at the end of the school year. These students were typically in grade 9 although there were some grade 10 students. In each participating school, the comparison group included students who took Algebra I but did not enroll in ICT in the same grade level, school, and year as students in ICT.

This study had four cohorts of students, defined by the year students took Algebra I. Not all cohorts were included in every outcome. All cohorts were included in the most proximal outcome that occurs at the end of the intervention: Algebra I achievement on the state assessment. Cohorts 1, 2, and 3 were included in the geometry achievement outcome that typically occurs at the end of the year following the cohort year because students typically take geometry after Algebra I. However, we found that this was not always the case as some students took Algebra II after Algebra I. Cohorts 1, 2, and 3 were also included in the "earning credit in Algebra II or higher" outcome. Again, while students typically take Algebra II after geometry, there were some students who took Algebra II in the year directly following their cohort year. Finally, cohorts 1 and 2 were included in the "earning credit in college-level math or computer science courses" outcome since this typically occurs in grade 11 or 12. This outcome was only measured for students who attended schools that offered dual enrollment math, Advanced Placement math, and/or Advanced Placement computer science. Table 3 illustrates which outcomes were measured for each cohort.

Table 3. Outcomes by cohort

Cohort	2020–21	2021–22	2022–23	2023–24
Cohort 1 **Treatment (T):** Students enrolled in ICT and Algebra I in grade 9 or 10 in 2020–21 **Comparison (C):** Students enrolled in Algebra I but did not enroll in ICT in same grade/school in 2020–21	End of ICT intervention: Algebra I achievement on state assessment	Earning credit in Algebra II or higher Geometry achievement on state assessment	Earning credit in Algebra II or higher Earning credit in college-level math or computer science courses	Earning credit in Algebra II or higher Earning credit in college-level math or computer science courses
Cohort 2 **T:** Students enrolled in ICT and Algebra I in grade 9 or 10 in 2021–22 **C:** Students enrolled in Algebra I but did not enroll in ICT in same grade/school in 2021–22		End of ICT intervention: Algebra I achievement on state assessment	Earning credit in Algebra II or higher Geometry achievement on state assessment	Earning credit in Algebra II or higher Earning credit in college-level math or computer science courses
Cohort 3 **T:** Students enrolled in ICT and Algebra I in grade 9 or 10 in 2022–23 **C:** Students enrolled in Algebra I but did not enroll in ICT in same grade/school in 2022–23			End of ICT intervention: Algebra I achievement on state assessment	Earning credit in Algebra II or higher Geometry achievement on state assessment
Cohort 4 **T:** Students enrolled in ICT and Algebra I in grade 9 or 10 in 2023–24 **C:** Students enrolled in Algebra I but did not enroll in ICT in same grade/school in 2023–24				End of ICT intervention: Algebra I achievement on state assessment

Source: Education Northwest.

Design and Measures

Independence of the Impact Evaluation

The Education Northwest evaluation team is not affiliated with LSU and played no role in the development or implementation of the intervention. Education Northwest worked with the LSU team on the evaluation design. The evaluation team then independently executed the impact evaluation. Impact evaluation activities included setting up data-sharing agreements with participating parishes and schools; collecting administrative data; and conducting data cleaning, analysis, and reporting. This final report was not subject to the approval of the project director or other staff members who conceptualized and implemented the intervention.

Pre-Registration of the Study Design

The evaluation team pre-registered the study design with the Registry of Efficacy and Effectiveness Studies (REES). The registry number is 10000.2v1.

This study had some changes from the pre-registered design. The pre-registered study design included separate research questions for the impact of the intervention on earning credit in college-level (i.e., dual enrollment/Advanced Placement) math and the impact of the intervention on earning credit in college-level (i.e., Advanced Placement) computer science. The evaluation team chose to combine earning credit in college-level math and college-level computer science into a single outcome because very few students took AP computer science. Rather than remove the computer science outcome from the study, we combined it with the college-level math outcome since both outcomes fall within the same domain.

The sample size for earning credit in college-level math was also quite small. Since all students in our sample started in Algebra I, the highest math course they could conceivably reach within the study period was Algebra II. Therefore, we also included the outcome of earning credit in Algebra II so that we could understand ICT's impact on a more common math course outcome related to algebra achievement among study participants.

Design

This study employed a within-school student-level quasi-experimental design using propensity score weighting and was designed to meet What Works Clearinghouse standards with reservations. Students who took ICT concurrently with Algebra I in grade 9 or 10 were matched to other students in the same school, grade level, and year who took Algebra I and did not take ICT. The study established baseline equivalence for the treatment and comparison students on pre-intervention socioeconomic status, as measured by free or reduced-price lunch eligibility, and baseline (grade 7 or 8) math state assessment scores.

We employed inverse propensity score weighting to adjust our outcome models for nonrandom selection into ICT and isolate its effect on student outcomes. For each of the analytic samples for the four outcomes, we estimated students' propensity score, or their probability of enrolling in ICT concurrently with Algebra I based on observed characteristics.

The generic propensity score model is given in equation 1 in which ICT_{ik} is an indicator for ICT enrollment, taking the value of 1 if a student *i* in school *k* enrolls in ICT and 0 if not. Students who did not successfully complete ICT (earn a passing grade) remained in the treatment group.

1.

$$log\left(\frac{\Pr(ICT_{ik}=1)}{1-\Pr(ICT_{ik}=1)}\right) = \beta_0 + \zeta_k + \beta_1 x_{ik} + \varepsilon_{ik}$$

In equation 1, x_{ik} is a vector of student characteristics (demographics and baseline math state assessment performance from grade 7 or 8) for student *i* in school *k*. This is a two-level regression model with a random effect at the school level, ζ_k.

We calculated the weight for each student *i* in school *k* as follows (equation 2). The resulting values were used to weight all regressions described below. In equation 2, ICT_{ik} was again the indicator for ICT enrollment as described above and $\widehat{p_{ik}}$ was the predicted probability obtained from the model above for student *i* in school *k*.

2.

$$\omega_{ik} = \frac{ICT_{ik}}{\widehat{p_{ik}}} + \frac{1-ICT_{ik}}{1-\widehat{p_{ik}}}$$

To assess program effects, we estimated weighted multilevel regression models that included random effects for schools. The generic outcome model for all outcomes is provided in equation 3. Statistical models included the inverse propensity score as weights (defined in equation 2) to adjust our outcome models for nonrandom selection into ICT and isolate its effect on student outcomes.

3.

$$y_{ik} = \beta_0 + \zeta_k + \beta_1 ICT_{ik} + \beta_2 x_{ik} + \gamma Cohort_{ik} + \varepsilon_{ik}$$

In this model, the coefficient of interest is β_1, which represents the average causal effect of enrollment in ICT on the given outcome. Again, students who did not successfully complete ICT (earn a passing grade) remained in the treatment group.

Measures

This study includes four student-level outcome measures: (1) Algebra I achievement on the state assessment, (2) geometry achievement on the state assessment; (3) earning credit in Algebra II or above; and (4) earning credit in college-level math or computer science. Table 4 describes key characteristics regarding these measures including their domain, descriptions, and timing of the baseline and outcome measures.

Table 4. Description of outcome measures

What Works Clearinghouse outcome domain	Algebra	Geometry	Progressing in pre-K–12 education	College readiness
Student-level outcome	Algebra I achievement	Geometry achievement	Earning credit in Algebra II or higher math course	Earning credit in college-level math or computer science
Outcome description	Total score (scale score, continuous) on LEAP 2025 Algebra I state assessment	Total score (scale score, continuous) on LEAP 2025 Geometry state assessment	Binary variable indicating whether student earned credit in Algebra II or higher math courses	Binary variable indicating whether student earned credit in dual enrollment math, Advanced Placement (AP) Calculus, or AP computer science course(s) at a school where these courses were offered
Expected grade level of measurement	Grade 9 or 10	Grade 10 or 11	Grade 10[a], 11 or Grade 12	Grade 11 or Grade 12
Baseline measures[b]	Grade 7/8 LEAP math scaled score	Grade 7/8 LEAP math scaled score	Grade 7/8 LEAP math scaled score Grade 9 FRPL status	Grade 7/8 LEAP math scaled score Grade 9 FRPL status

FRPL = Free or reduced-price lunch eligible. LEAP = Louisiana Educational Assessment Program.

[a] While the typical math sequence is Algebra I, geometry, and then Algebra II. Some students in the sample took Algebra II in grade 10 and then geometry.

[b] LEAP tests were cancelled due to the COVID-19 pandemic in spring 2020, so grade 8 scores are not available for cohort 1 grade 9 students and cohort 2 grade 10 students. For these students, we use grade 7 LEAP math test scores instead.

Source: Education Northwest.

KEY BASELINE MEASURES

Middle school LEAP math scaled score. The Louisiana Educational Assessment Program (LEAP) is a standardized testing program designed to measure students' mastery of the state's academic standards in core subjects, including English language arts (ELA), mathematics, science, and social studies. These assessments help evaluate students' readiness for the next grade level and their preparedness for future academic challenges. Student performance is reported as one of five performance levels: advanced, mastery, basic, approaching basic, or unsatisfactory. LEAP is administered annually to students in grade 3 through high school. We used the continuous scale score instead of the coarser performance levels as the baseline measure in our propensity score and impact models. The scaled scores range from 650 to 850 for all subjects, except science. For the most part, we used students' grade 8 math scale scores as the baseline measure. However, cohort 1 grade 9 students and cohort 2 grade 10 students did not take grade 8 state assessments because of the COVID-19 pandemic, so we used their grade 7 math scale score as their baseline measure.

The free or reduced-price lunch (FRPL) measure is an important indicator of socioeconomic status derived from Louisiana's administrative data. It reflects the proportion of students eligible for FRPL programs under the National School Lunch Program. Eligibility for these programs is based on household income levels relative to the federal poverty guidelines. In Louisiana, student eligibility for FRPL is collected and maintained within the state's administrative data systems. This measure serves as a proxy for identifying students from low-income families.

OUTCOME MEASURES

Algebra I and geometry achievement. The LEAP 2025 Algebra I test produces measures of student performance in algebra overall as well as within three algebra subcategories: interpreting functions, solving algebraically, and solving graphically/rate of change. The LEAP 2025 geometry test produces measures of student performance in geometry overall as well as within two subcategories: congruence transformations/similarity and similarity in trigonometry/modeling & applying. We used the overall continuous scale score as the outcome in our impact models.

Earning credit in Algebra II or higher math course. The measure of earning credit in an Algebra II or higher math course is an indicator used to assess students' continued algebra achievement and progression and achievement in mathematics courses required to earn the TOPS University Diploma, namely Algebra II, during their high school education. Among the students who achieved this outcome, 98 percent earned credit in Algebra II; the remaining 2 percent of students somehow bypassed Algebra II and earned credit in more advanced math courses. As a result, this measure tracks whether students have successfully completed Algebra II or a higher math course, measured by earning credit in this course.

Earning credit in college-level math or computer science. This measure tracks whether students have successfully completed and earned academic credit for AP Calculus; dual enrollment math, such as trigonometry; or AP Computer Science courses, specifically AP Computer Science A and AP Computer Science Principles. Only students at schools where these courses are offered were included in this outcome measure.

Sample Sizes

The treatment group comprises grade 9 and 10 students who took ICT concurrently with Algebra I in 2020–21, 2021–22, 2022–23, or 2023–24, and the comparison group comprises students in the same grade level, school, and year who took Algebra I and not ICT. Table 5 summarizes the sample size per outcome measure.

Table 5. Analytic sample sizes for each outcome

Outcome measure	Comparison group	Treatment group	Total
Algebra I achievement on state assessment	4,449	1,078	5,527
Geometry achievement on state assessment	2,666	599	3,265
Earning credit in Algebra II or above	4,313	847	5,160
Earning credit in college-level math or computer science	1,678	451	2,129

Note: Algebra I achievement on state assessment includes students from all cohorts. The geometry achievement on state assessment and earning credit in Algebra II or above outcomes include students from the 2020–21, 2021–22, and 2022–23 cohorts. Earning credit in in college-level math or computer science includes students from the 2020–21 and 2021–22 cohorts.

Source: Education Northwest.

Data Analysis and Findings

Baseline Equivalence

To test for baseline equivalence, we used a weighted multilevel linear regression to estimate the difference in middle school math achievement on the state assessment between the treatment and comparison students included in each outcome measure.

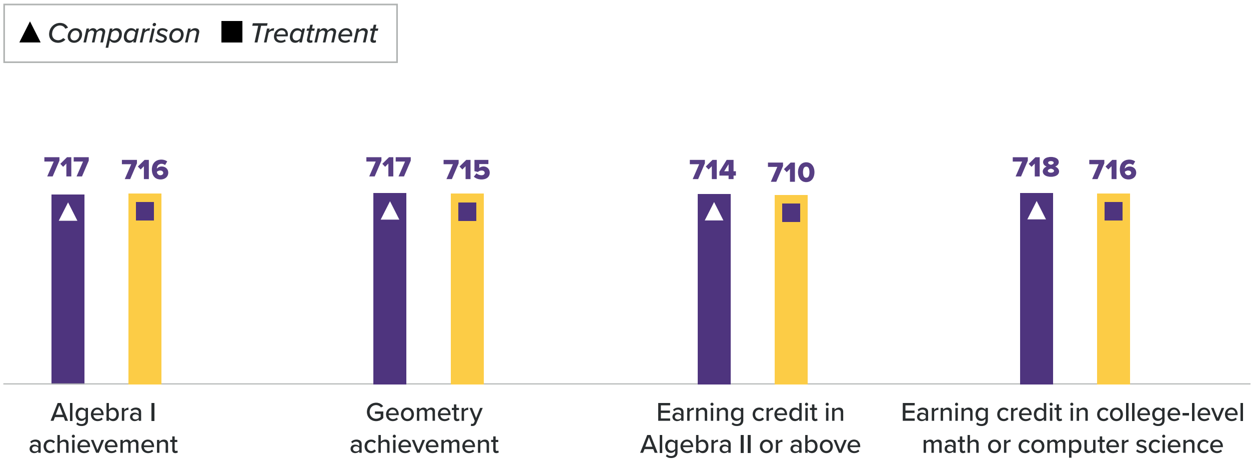
4. $$y_{ik} = \beta_0 + \zeta_k + \beta_1 ICT_{ik} + \gamma Cohort_{ik} + \mu_{ik}$$

In equation 4, Y_{ik} is the grade 7/8 LEAP score of student i in school k, ζ_k is the random school effect of school k, β_1 is the mean effect of ICT enrollment, ICT_{ik} is a binary indicator of ICT enrollment for student i in school k, γ is a vector of cohort effects, $Cohort_{ik}$ is a vector of cohort indicators for student i in school k, and μ_{ik} is the residual for student i in school k. The sample is weighted using the same inverse probability weights generated from the propensity score model (equation 1 and 2 above). We transform the coefficient associated with ICT enrollment, β_1, to a standardized difference (Hedges' g for continuous measures).

Baseline equivalence is confirmed for the sample of students included in the most proximal outcome of Algebra I achievement and for the outcome of geometry achievement, as the absolute value of the standardized difference is smaller than 0.05 (see table B1 in appendix B). However, the absolute value of the standardized difference for middle school math state assessment scores for the earning credit in Algebra II or above and college-level math or computer science are 0.06 and 0.07, which are greater than 0.05 but less than 0.25. In all outcome models, we account for this by including middle school math achievement on the state assessment as a covariate.

Figure 1 displays the propensity score weighted mean middle school math achievement on the state assessment for the treatment and comparison groups by outcome. All of these scores fall in the "approaching basic" achievement level for middle school math.

Figure 1. Baseline middle school math achievement for comparison and treatment groups

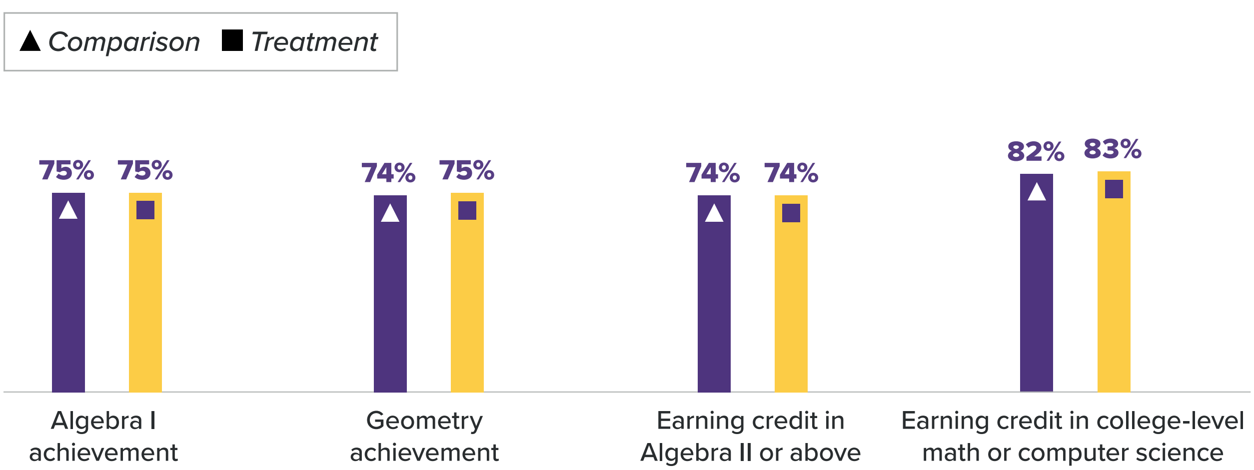


Note: Mean based on propensity score weighting.

Source: Education Northwest.

Testing for baseline equivalence of FPRL eligibility is similar, but we used a multilevel logistic regression, as the measure is binary. We transformed the coefficient associated with ICT enrollment, β_1, to a standardized difference (the Cox Index for binary measures). Baseline equivalence was confirmed for FRPL eligibility as the absolute value of the standardized difference is smaller than 0.05 (see table B1 in appendix B). Figure 2 displays the propensity score weighted mean percentage of students eligible for FRPL for the treatment and comparison groups by outcome.

Figure 2. Percentage of free or reduced-price lunch–eligible students for comparison and treatment groups



Note: Mean percentage based on propensity score weighting.

Source: Education Northwest.

In addition, we report on differences between relevant student demographics for the intervention and comparison students in table B1 in appendix B (i.e., gender, race/ethnicity, English learner and special education status).

Program Effects

Findings from the analysis, detailed in table 6, demonstrate that students who participated in ICT and Algebra I concurrently scored 3.8 points higher on the LEAP 2025 Algebra I state assessment than students who only took Algebra I, and this result is statistically significant.

Examining the first three cohorts, students who participated in ICT and Algebra I concurrently scored 2.4 points higher on the LEAP 2025 geometry state assessment than those who only took Algebra I, but the finding is not conclusive as the result is not statistically significant.

Examining the first three cohorts, the analysis finds that ICT had a statistically significant and positive impact on the likelihood of earning any credit in Algebra II or higher math courses. Students who participated in ICT were 10 percentage points more likely to take and pass Algebra II or higher than their counterparts who did not take ICT.

Finally, examining the first two cohorts, students who participated in ICT and Algebra I concurrently were slightly more likely to earn credit in college-level math or computer science courses, but the finding is not conclusive as the result is not statistically significant.

Table 6. Regression results examining the effect of ICT on outcomes

Predictor	Algebra I achievement on state assessment	Geometry achievement on state assessment	Earning credit in Algebra II or above	Earning credit in college-level math or computer science
Treatment (ICT enrollment)	3.8* (1.8)	2.4 (1.5)	0.1*** (0.02)	0.002 (0.01)
Gender (Reference: Male)				
Female	1.4 (1.4)	0.5 (1)	0.1*** (0.03)	0.02* (0.01)
Grade (Reference: Grade 9)				
10	-7.7* (3)	-2.2 (2.4)	-0.1 (0.4)	-0.02* (0.01)
Race/ethnicity (Reference: White)				
Asian	7 (5.4)	6* (2.7)	0.1* (0.06)	0.3 (0.1)
Black	-9.6** (3.3)	-5.4**(1.9)	0.03 (0.05)	0.01 (0.01)
Latino/a/x	-0.7 (2.4)	0.9 (2.5)	0.01 (0.06)	0.05*** (0.01)
English learner status (Reference: Not classified)				
Classified as English learner	-10.7*** (2.7)	-9.1** (3.2)	-0.02* (0.05)	-0.1** (0.02)
Special education status (Reference: Not in special education)				
In special education	-6.8* (2.7)	-1.6 (1.8)	-0.2*** (0.4)	0.01 (0.02)
Free or reduced-price lunch (Reference: Not eligible)				
Free or reduced-price lunch eligible	-3.6 (2.3)	-4.2* (2.1)	-0.03 (0.03)	0.01 (0.02)
Cohort (Reference: 2020–21)				
2021–22	-2 (4.3)	-2.6 (2.3)	-0.1* (0.5)	-0.05*** (0.01)
2022–23	-2.6 (4.4)	-7.2*** (1.9)	-0.6*** (0.1)	–
2023–24	-7.2 (4.6)	–	–	–
Middle school math score	0.2 (0.1)	0.1 (0.1)	0.001 (0.001)	0.001* (0.001)
Model N	5,527	3,265	5,160	2,129

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Notes: Models use propensity score weighting. Regression results for the outcomes of earning credit in Algebra II or above and earning outcome in college-level math or computer science are presented as percentage points. Robust standard errors are shown in parentheses. Geometry and earning credit in Algebra II or above outcomes include students from the 2020–21, 2021–22, and 2022–23 cohorts. Earning credit in college-level math or computer science only includes students from the 2020–21 and 2021–22 cohorts.

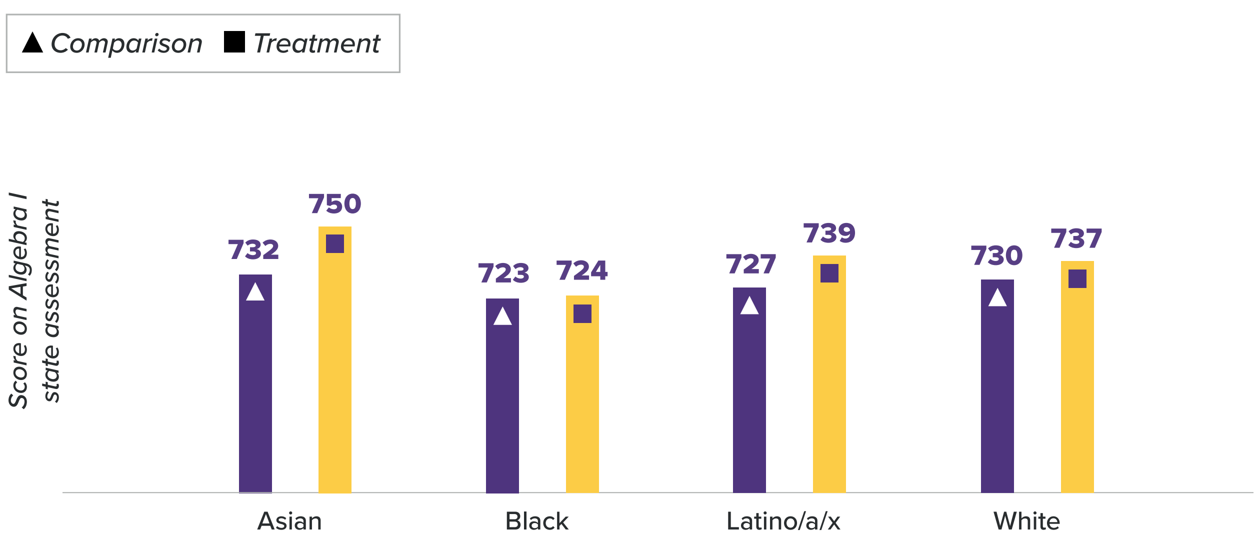
Source: Education Northwest.

SUBGROUP EFFECTS BY RACE/ETHNICITY

Using interaction effects, we examined intervention effects by race/ethnicity for the two outcomes with statistically significant findings. Across all racial/ethnic groups, ICT had a positive effect on students' Algebra I achievement on the state assessment and likelihood of earning credit in Algebra II or higher. However, this positive effect was stronger for some student groups. ICT had a greater positive effect on Algebra I achievement on the state assessment for Asian, White, and Latino/a/x students compared to Black students (figure 3). In fact, ICT had a minimal effect on the Algebra I achievement of students who identify as Black.

Additionally, ICT's positive effect on the likelihood of earning credit in Algebra II or higher was strongest for students who identify as Asian (figure 4). For full regression results see table C1 in appendix C.

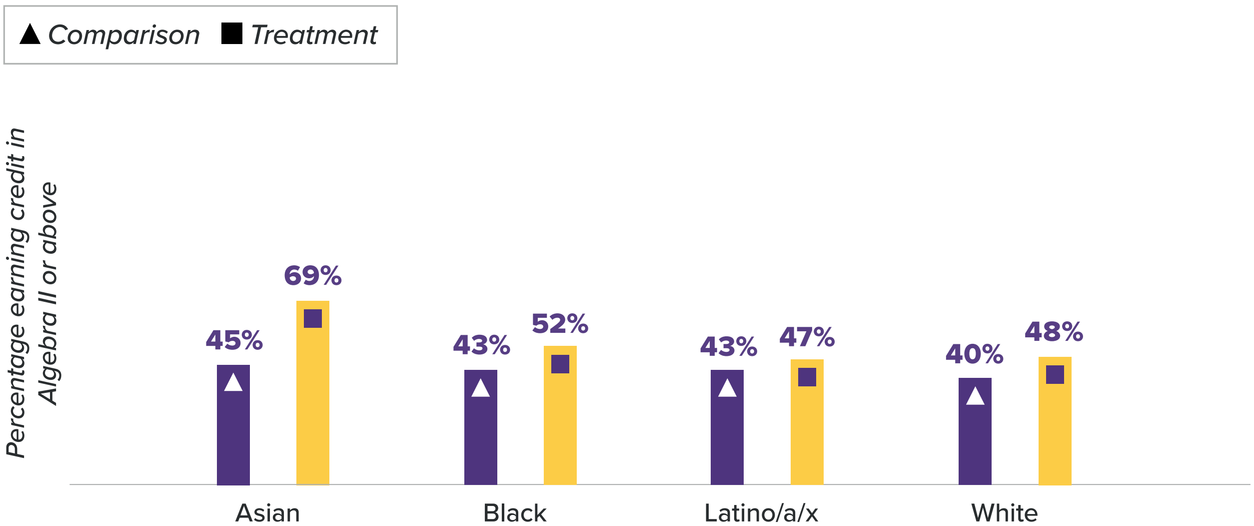
Figure 3. ICT had a larger effect on the Algebra I test score achievement of Asian, White, and Latino/a/x students compared to Black students



Note: Algebra I state assessment achievement includes students from the 2020–21 through 2023–24 cohorts. The results reflect predicted test scores generated from propensity score–weighted regression models that include an interaction between ICT participation and student race/ethnicity. For full regression results see table C1 in appendix C.

Source: Education Northwest.

Figure 4. ICT had a stronger effect on earning credit in Algebra II or higher for Asian, Black, and White students than for Latino/a/x students



Note: Earning credit in Algebra II or above outcomes include students from the 2020–21, 2021–22, and 2022–23 cohorts. The results reflect predicted probability of earning credit in Algebra II or above generated from propensity score–weighted regression models that include an interaction between ICT participation and student race/ethnicity. For full regression results see table C1 in appendix C.

Source: Education Northwest.

Discussion

This impact evaluation involved more than two dozen high-need high schools where the majority of students were from low-income families. Across these schools, this evaluation found that ICT met its goals of using a computational thinking course to support students' mathematics achievement at the end of the intervention. ICT boosted students' scores on the LEAP 2025 Algebra I assessment by almost four points. The significant increase in the likelihood of earning credit in Algebra II or higher also aligns with the intervention's goals, and the magnitude of this effect is large, suggesting that ICT enrollment enhanced students' math trajectories, which is crucial for college readiness and STEM careers.

This study raises several directions for future research. First, future implementation research should explore what represents adequate implementation fidelity of ICT. Despite ICT not meeting adequate fidelity standards for the key components of ICT teacher training and teacher recruitment and student enrollment, the intervention still had positive impacts, suggesting that implementation fidelity standards may have been set higher than necessary to achieve a positive impact. Additionally, few classrooms made it all the way through the ICT curriculum. On average, ICT classrooms completed about 63 percent of the ICT curriculum. Future research should explore what lessons, units, and competencies are most important for algebra and higher math course achievement and how ICT facilitates the transfer of skills to mathematics and other subject areas.

Another key direction for research on ICT is to explore its heterogenous effects on different student groups. ICT had a minimal impact on Black students' Algebra I achievement. This is significant given that nearly two-thirds of study participants were Black students. ICT is successful at reaching student populations that are historically underserved in computer science education, so an important next step is to ensure all students benefit equally from ICT.

Overall, this study supports further scaling, research, and evaluation of ICT. Continued research is needed to refine the understanding of whether and how ICT impacts student outcomes and to develop strategies to maximize its benefits.

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Appendix A. Logic Model

Table A1. Introduction to Computational Thinking logic model

Key support components	Direct components	Mediators	Short-term outcomes	Long-term outcomes
1. ICT teacher training that comprises: • 24-day training course with certification[a] • Community of practice group coaching sessions • Prescriptive plan and one-on-one coaching sessions (as needed) • Online community of practice portal available during the 24-day training and school year to access live help from developers or experienced teachers • Refresher training (half-day) **2. ICT online portal where teachers and students have access to curriculum materials that include:** • Teacher instructional materials (4 units and teacher solutions)[b] • Student learning materials (4 units) **3. Teacher recruitment and student enrollment** • Teachers recruited to instruct ICT • Students encouraged to enroll in ICT **4. ICT train-the-trainer session** • One-day train-the-trainer session for instructors to lead the ICT training course and facilitate a community of practice	• Teachers instruct the ICT course with skill and fidelity (complete units and assignments in appropriate time and sequence) • Students engage in ICT learning activities	• Teachers demonstrate increased understanding of programming, computational thinking, and mathematics • Teachers increase skills in online and adult pedagogy • Students exhibit increased understanding of fundamental mathematical concepts and computational thinking • Students exhibit increased engagement and interest in STEM courses and pathways	• Districts/schools experience: • Increased number of schools offer ICT • Increased number of teachers instruct ICT • Equitable representation in ICT course as in school enrollment • Increased student achievement in algebra and geometry • Students more likely to earn credits in upper-level algebra and college-level math and computer science courses	• Trained cadre of experienced ICT teachers • Larger, more diverse STEM teacher workforce • Increased high school graduation rates • Larger, more diverse STEM workforce • Sustained, or increased, enrollment in ICT by diverse groups of students

[a] Beginning in summer 2023, this was changed to a 12-day training course.

[b] Beginning in fall 2022, an automated grading feature was added.

Appendix B. Baseline Equivalence

Table B1. Results from baseline equivalence assessment by outcome

	Comparison group			Treatment group				
Measure	**Sample size**	**Mean**	**SD**	**Sample size**	**Mean**	**SD**	**Treatment – comparison difference**	**Standardized difference**
Outcome: Algebra I achievement on state assessment								
LEAP middle school math performance	4,449	717	50	1078	716	63	-1	0.004
Free or reduced-price lunch	3,487	75%	–	844	75%	–	0%	0.01
Male	2,216	49%	–	573	51%	–	2%	0.04
Female	2,223	51%	–	505	49%	–	-2%	0.04
Asian	64	1%	–	18	1%	–	0%	0.02
Black	2,735	67%	–	687	66%	–	-1%	0.03
Hispanic	614	13%	–	93	11%	–	-2%	0.06
White	984	20%	–	243	22%	–	2%	0.06
English learner	299	6%	–	58	5%	–	-1%	0.05
Special education	512	10%	–	79	10%	–-	0%	0.002
Outcome: Geometry achievement on state assessment								
LEAP middle school math performance	2,666	717	57	599	715	70	-2	0.03
Free or reduced-price lunch	2,110	74%	–	468	75%	–	1%	0.02
Male	1,293	47%	–	312	47%	–	0%	0.01
Female	1,373	53%	–	287	53%	–	0%	0.01
Asian	52	2%	–	16	2%	–	0%	0.02

	Comparison group			Treatment group				
Measure	**Sample size**	**Mean**	**SD**	**Sample size**	**Mean**	**SD**	**Treatment – comparison difference**	**Standardized difference**
Black	1,727	63%	–	402	66%	–	3%	0.06
Hispanic	348	18%	–	50	14%	–	-4%	0.1
White	523	19%	–	129	19%	–	0%	0.003
English learner	181	7%	–	24	6%	–	-1%	0.07
Special education	224	7%	–	39	9%	–	2%	0.07
Outcome: Earning credit in Algebra II or above								
LEAP middle school math performance	4,313	714	58	847	710	84	-4	0.07
Free or reduced-price lunch	3,390	74%	–	674	74%	–	0%	0.01
Male	2,145	49%	–	446	51%	–	2%	0.03
Female	2,168	51%	–	401	49%	–	-2%	0.03
Asian	70	2%	–	19	2%	–	0%	0.003
Black	2,635	65%	–	534	64%	–	-1%	0.01
Hispanic	646	15%	–	81	13%	–	-2%	0.07
White	936	20%	–	209	22%	–	2%	0.05
English learner	313	7%	–	33	5%	–	-2%	0.07
Special education	466	10%	–	57	10%	–	0%	0.01
Outcome: Earning credit in college-level math or computer science								
LEAP middle school math performance	1,678	718	29	451	716	27	-2	0.06
Free or reduced-price lunch	1,400	82%	–	401	83%	–	1%	0.03
Male	825	49%	–	247	57%	–	8%	0.16

Measure	Comparison group Sample size	Mean	SD	Treatment group Sample size	Mean	SD	Treatment – comparison difference	Standardized difference
Female	853	51%	–	204	43%	–	-8%	0.16
Asian	21	1%	–	10	1%	–	0%	0.01
Black	1,106	65%	–	290	65%	–	0%	0.0002
Hispanic	196	9%	–	36	6%	–	-3%	0.13
White	342	23%	–	113	28%	–	5%	0.1
English learner	145	7%	–	23	5%	–	-2%	0.1
Special education	180	9%	–	25	11%	–	2%	0.07

SD = Standard deviation.

Note: Mean and percentage are based on propensity score weighting. Geometry and earning credit in Algebra II or above outcomes include students from the 2020–21, 2021–22, and 2022–23 cohorts. Earning credit in college-level math or computer science only includes students from the 2020–21 and 2021–22 cohorts.

Source: Education Northwest.

Appendix C. Subgroup Effects

Table C1. Regression results examining the effect of ICT on outcomes with race/ethnicity interaction

Predictor	Outcome: Algebra I achievement on state assessment	Outcome: Geometry achievement on state assessment	Outcome: Earning credit in Algebra II or above	Outcome: Earning credit in college-level math or computer science
Treatment (ICT enrollment)	6.7* (2.9)	-0.1 (2.2)	0.1 (0.05)	-0.04* (0.01)
Gender (Reference: Male)				
Female	1.5 (1.4)	0.5 (1)	0.1*** (0.03)	0.01* (0.01)
Grade (Reference: Grade 9)				
10	-7.7* (3)	-2.3 (2.6)	-0.1 (0.4)	-0.02* (0.01)
Race/ethnicity (Reference: White)				
Asian	2.3 (4.9)	-0.3 (1.7)	0.1* (0.06)	0.1* (0.1)
Black	-6.6** (2.2)	-6.6**(2)	0.02 (0.03)	-0.02 (0.01)
Latino/a/x	-3.2 (3.2)	-3.7 (2.2)	0.02 (0.05)	0.05 (0.02)
EL (Reference: Not classified)				
Classified as English learner	-10.2** (2.6)	-8.8** (3.4)	-0.03* (0.05)	-0.1** (0.02)
Special education status (Reference: Not in special education)				
In special education	-6.6* (2.6)	-1.4 (1.7)	-0.2*** (0.3)	0.01 (0.02)
Free or reduced-price lunch (Reference: Not eligible)				
Free or reduced-price lunch eligible	-3.4 (2.3)	-3.8 (2)	-0.03 (0.03)	0.01 (0.01)

Predictor	Outcome: Algebra I achievement on state assessment	Outcome: Geometry achievement on state assessment	Outcome: Earning credit in Algebra II or above	Outcome: Earning credit in college-level math or computer science
Cohort (Reference: 2020–21)				
2021–22	-2.1 (4.3)	-2.6 (2.3)	-0.1* (0.5)	-0.05*** (0.01)
2022–23	-2.7 (4.3)	-7.1*** (2)	-0.6*** (0.1)	–
2023–24	-7.1 (4.4)	–	–	–
Middle school math score	0.2 (0.1)	0.1 (0.1)	0.001 (0.001)	0.001** (0.0002)
ICT interaction with race/ethnicity (Reference: White)				
Asian	10.7 (6.6)	12.9* (5.4)	0.2 (0.1)	0.3 (0.2)
Black	-6 (3.6)	1.8 (2.9)	0.01 (0.1)	0.04* (0.02)
Latino/a/x	5.4 (4.7)	9.7* (4.6)	-0.03 (0.1)	0.02 (0.04)
Model N	5,527	3,265	5,160	2,129

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Notes: Models use propensity score weighting. Regression results for the outcomes of earning credit in Algebra II or above and earning outcome in college-level math or computer science are presented as percentage points. Robust standard errors are shown in parentheses. Geometry and earning credit in Algebra II or above outcomes include students from the 2020–21, 2021–22, and 2022–23 cohorts. Earning credit in college-level math or computer science only includes students from the 2020–21 and 2021–22 cohorts.

Source: Education Northwest.