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Special Research Feature and Forum

# Lifelong Learning in Adult Education: A 12-Year Longitudinal Study of Participation and Skill Growth

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## Abstract

Analyses of administrative data from one state's Title II adult education programs between 2007 and 2019 focus on the longitudinal participation patterns and skill growth of nearly half a million adult students. In contrast with single program year reports, adults' participation and learning is seen across multiple years and multiple providers. One third of students participated in multiple years, and over one third participated in multiple programs. Literacy and numeracy skill growth is systematically related to long-term instructional hours attended over time and across programs. These results provide new insights into how adult education supports long-term skill growth and lifelong learning. Implications of these extended participation patterns and long-term skill growth are considered for programs and policy.

Education and literacy have long been believed to be central to our social and economic wellbeing (Desjardins, 2008; Kirsch et al., 2016; Martin, 2018; Reder & Bynner, 2009; Sands, 2021). In addition to the education individuals attain in their first cycle of schooling, their continued education as adults is also associated with better life outcomes and wellbeing (Duckworth & Cara, 2012; Jenkins & Wiggins, 2015; Tuijnman, 1990; Vera-Toscano et al., 2017). There is growing evidence from numerous international and national surveys that literacy and numeracy skills are positively associated with a range of economic and social outcomes.

Hanushek et al. (2015) highlighted the economic returns to cognitive skills such as literacy and numeracy using Mincer-like wage equation models. A variety of social outcomes including health, social trust, political efficacy, and civic engagement have been examined in surveys such as the Adult Literacy and Lifeskills (ALL) survey, the International Adult Literacy Survey (IALS), and most recently the Survey of Adult Skills (also known as the Program for the International Assessment of Adult Competencies or PIAAC). Analyses of these survey data generally find that both education and literacy skills are associated with better social outcomes (Borgonovi & Burns, 2015; Desjardins, 2008; Costa et al., 2014; Duckworth, 2012; OECD, 2013). In these studies, individuals with higher levels of assessed literacy or numeracy skills are likely to have better economic and social outcomes, even after controlling for demographic and educational attainment variables. Hampf et al. (2017) provide various types of evidence that these observed relationships between skills and economic outcomes are causal in nature.

In addition to supporting important economic and social outcomes, literacy and numeracy skills are essential for lifelong learning and sustainable development. High levels of adult literacy and numeracy are an integral part of the United Nations Sustainable Development Goal (SDG) 4, being both prerequisites for and the by-product of lifelong learning. Policies and programs that foster increased literacy and numeracy skills effectively support SDG 4, designed to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (UNESCO Institute for Statistics, 2018, p. 7).

## Impact of Participation in Adult Education on Foundational Skill Development

Adults who have not completed secondary education often participate in adult education programs to improve their foundational skills; prepare for tests that provide alternative secondary credentials; or transition into postsecondary education, training, or higher paying jobs. As important as these pathways are for adults and their families, and for society more generally, there is relatively little research that rigorously examines the long-term impact and effectiveness of these programs (Beder, 1999; Cross, 1981; Reder & Bynner, 2009). Most research on adult literacy development looks only at short-term changes as students pass through single adult education programs. Most studies use short follow-up intervals and include only program participants, making it difficult to see the longer-term patterns of program participation and persistence and to assess the long-term impact of program participation (Beder, 1999; Brooks et al., 2001; Lesgold & Welch-Ross, 2012; Reder, 2014; Smith, 2009). In this sense, much of the existing research is not conceptualizing program participation and skill development as part of lifelong learning.

Although program evaluation and accountability reports typically show small skill gains for program participants, these studies rarely include comparison groups of nonparticipants, and many studies that do include such controls have not found statistically significant program impact on skill development (Friedlander & Martinson, 1996; Reder, 2019; Smith, 2009; Vorhaus et al., 2011; Wolf & Evans, 2011). Secondary reviews and meta-analyses of numerous research and evaluation studies of adult education programs have found little rigorous evidence of program impact on adults' skill growth (Beder, 1999; Brooks et al., 2001; Smith, 2009). Experimental comparisons of skill gains in different adult education instructional conditions, such as those reviewed by Miller et al. (2011), typically fail to show effects of instructional hours on skill growth, raising questions about the logic model connecting instruction to foundational skill development. These inconsistent findings prompted interest in research examining skill growth across the adult life span using repeated measurements of skill in longitudinal studies.

## The Need for Longitudinal Research on Adult Foundational Skill Development

Reder and Bynner (2009) point out the importance of longitudinal research for understanding program participation and skill development processes and note there are very few longitudinal studies of adult literacy and numeracy development, and even fewer that examine the relationship between participation in adult education and skill growth. One such study, The Longitudinal Study of Adult Learning (LSAL), followed a representative sample of about 1,000 adults from the target population for adult education in a metropolitan area (Reder, 2009). Over an eight-year period, repeated interviews were conducted about individuals' education, work, and community experiences along with repeated standardized assessments of their literacy skills and reports about how those skills were used in everyday life. For those who participated in adult education, observed trajectories of participation and skill growth often extended over multiple years.

Qualitative researchers (e.g., Pickard, 2021; Heath, 2012; Silva et al., 1998) concur with LSAL's findings that adults often have trajectories of participation in adult education programs that extend over multiple years and encompass discrete periods of participation. Previous research has characterized these patterns of participation in terms of interactions between individuals' goals, dispositional characteristics, and situational factors in the external environment (Pickard, 2021; Silva et al., 1998; Yang, 1998). Dispositional characteristics that affect motivation and persistence during learning include students' goals, goal-directed thinking and action based on hope theory, and self-perceptions of competency (Mellard et al., 2013). Situational barriers are life circumstances that impede individuals' ability to participate, such as work schedules, availability of affordable childcare, or transportation (Comings, 2009; Comings et al., 1999; Cross, 1981; Pickard & Belzer, 2020; Sticht et al., 1998). Demographic characteristics including age, gender, prior education, and language status are commonly found to be cross-cutting variables shaping the participation patterns (e.g., Greenberg et al., 2013).

In addition to tracking adults' patterns of participation, the LSAL data enabled careful modeling of skill development over time. A variety of linear growth models compared the

skill development of matched program participants and nonparticipants. Analyses of the models demonstrate that the impact of program participation on skill growth takes place gradually over time, often taking three to five years to fully develop (Reder, 2014, 2019). Further analyses of the LSAL data show reciprocal effects over time between skill growth and skill use in everyday life, providing strong support for practice engagement theory (PET) (Reder, 1994, 2009, 2019; Sheehan-Holt & Smith, 2000; Smith, 1996, 2009).

Purcell-Gates et al. (2002) found that the short-term impacts of adult education programs are primarily on students' engagement in literacy practices rather than on their assessed literacy skills. Given the initial impact of programs on practice engagement, PET predicts that longer-term skill growth will gradually occur. In addition to being rigorously tested in the LSAL study, PET also has empirical support from large-scale cross-sectional studies of national adult populations (Jonas, 2018; Sheehan-Holt & Smith, 2000). It has also been tested longitudinally with a broad, nationally representative population sample in Germany's PIAAC-L study, a multi-year longitudinal extension of Germany's original PIAAC study (Reder et al., 2020). These findings provide further support for a logic model of program impact on skill growth in which the skill development effects take time to fully develop after the onset of participation. It is clear from this research that longitudinal analyses of both program participation and skill gain are needed to better understand and demonstrate the impact of adult education programs on skill development.

## Longitudinal Research on Adult Skills Based on Administrative Data

Longitudinal studies that follow individual adults over time are rare and expensive to conduct. Very few include repeated measurement of skills and details of participation in adult education and a range of life outcome measures. For this reason, longitudinal administrative data sets that contain such data could be helpful to adult education researchers. The research reviewed above indicates that although adult education programs do have considerable long-term impact on skill development, much of that impact typically does not show up in the short term. Thus, there is a major misalignment between short-term outcomes that programs are accountable for and the long-term outcomes that programs actually produce. If the current study finds this misalignment in administrative data sets, then states, programs, and advocates of adult foundational education will have a compelling reason to use administrative data longitudinally across program years.

In the United States, most states have developed Statewide Longitudinal Data Systems (SLDSs) that link administrative K-12, postsecondary, and employment data. For almost all states, however, adult education data are not included in these SLDSs. On the other hand, the large national network of adult education programs in the United States receiving federal Title II WIOA[1] funding collect and report standardized administrative data about individual students' demographic characteristics, participation in classes, and assessed skills (Cherewka & Prins, 2022). These student-level records are passed to and aggregated by a designated state agency for annual reporting to the National Reporting System (NRS). The individual student records underlying state NRS reports are potentially very useful for research on adult education student participation patterns and skill development (Rose, 2009).

There have been several state-level studies of student participation and skill development using administrative records collected for NRS reporting. State agencies that have reported on relationships between participation and skill growth include the California Department of Education (2004) and the Connecticut State Department of Education (2009). California examined participation of nearly 500,000 ESL and ESL-Civics students participating in one of the four program years (PYs): 1999–2000, 2000–2001, 2001–2022, or 2002–2003. For almost all combinations of three instructional-hours categories (12–74 hours, 75–120 hours, 121 or more hours) and six initial NRS Educational Functioning Levels, students showed larger CASAS Reading test score gains within a single PY as a function of larger amounts of instructional time. This relationship was observed in each of the four PYs. Connecticut observed learning gains and attendance patterns of 33,578 ESL students participating in the five PYs between 2002–2003 and 2006–2007. Learning gains and attendance were

1 Title II programs, implemented under WIOA legislation starting in 2014, were previously operated under earlier legislation entitled WIA.

measured within a single PY on either matched CASAS Listening tests or matched CASAS Reading tests. Learning gains were positively related to instructional hours in each of the PYs observed. This positive relationship was observed even after controlling for students' prior education.

Young (2007) analyzed the relationship between instructional hours and skill gains measured by BEST Plus tests of English listening and speaking among nearly 6,600 selected adult ESL students in Massachusetts and Illinois over a 14-month period in 2004–2005. She observed a positive relationship between instructional hours and learning gains on these tests.

These studies examined ESL students' participation and skill gains within single PYs, not across multiple PYs. Other adult education students (ABE, ASE) were not part of these studies. Studies using administrative data to explore the relationship between participation and skill gains among multiple types of adult education students (ESL, ABE, and ASE) include Rose (2009), Tighe et al. (2013), and Yin et al. (2022).

Yin et al. (2022) analyzed relationships between students' test score gains and instructional hours while controlling for student, teacher, and program characteristics. Data were collected from one anonymous state from the 2008–2009, 2009–2010, and 2010–2011 PYs. They reported that about 20% of the students participated in multiple PYs. In addition, numerous students who participated in multiple programs or with multiple teachers or in multiple PYs did not have their administrative records linked via common student identifiers. Using three-level hierarchical linear regression models, the authors found significant positive relationships between instructional hours and test score gains (on multiple types of skill tests) while controlling for numerous student, teacher, and program variables. Their three-level models nested students within teachers within programs, so many details of participation patterns in which students had multiple teachers or programs were excluded from the analyses.

Tighe et al. (2013) used hierarchical latent growth models to identify adult education classrooms that had greater or lesser effectiveness in promoting adult students' literacy achievement in two Florida counties. They were able to include students who participated in multiple classrooms over time by using cross-classified random effects latent growth models. These models estimated classroom-level value-added effects on students' literacy achievement.

Rose (2009) analyzed the administrative data collected for the NRS by each of four anonymous states from the 2000–2001, 2001–2002, 2002–2003, and 2003–2004 PYs. In three of the four states, he found numerous students with attendance records in multiple PYs so that longitudinal records of student participation and outcomes were available. In the fourth state, however, students were assigned new identifiers in each PY so that no multi-year longitudinal records of students were available, and thus that state was omitted from the final analyses. He demonstrated that program participation along with educational and economic outcomes were substantially distorted by focusing on only single PY data as the NRS does. He found 22%, 26%, and 28% of students from the three states participated in more than one PY, comparable to the rate reported by Yin et al. (2022). These figures may underestimate multi-year attendance since neither Rose (2009) nor Yin et al. (2022) estimated the extent to which states may have missed aligning the identifiers for some students participating in multiple PYs.

Using data collected for NRS reporting purposes has important limitations that must be overcome to be useful for these research purposes. One important limitation arises because NRS reporting is in terms of single PYs. Within a single PY, states must report unduplicated counts of students served. Students participating in multiple classes or programs within a given PY are de-duplicated by states for reporting purposes. States do not, however, typically de-duplicate students across PYs. Many individual students who participate in multiple PYs may appear as distinct students, effectively masking longer-term patterns of participation and skill development. To better examine these extended patterns of participation and analyze their impact on skill growth, the present study will de-duplicate student records across teachers, programs, and PYs.

Although NRS started reporting periods of participation in PY 2017, these are reported within a single PY only.[2] By de-duplicating student records across PYs, the present

2 The assistance of Stephanie Cronen of the American Institutes for Research (AIR) in understanding the history and requirements of the NRS is gratefully acknowledged.

study will be able to see these longer-term patterns of student participation and skill development within the administrative data collected by programs and states. Another limitation of state-reported NRS data for our research purposes is the so-called "12-hour" rule. Students who do not attend classes for 12 or more hours within a PY are omitted from most NRS reporting. The analyses in the present study include these short episodes of participation.

## Research Questions

Using administrative adult education records from one state, the present study will address two major research questions:

- What are the characteristics of student participation patterns when linked across programs and over time?
- What are the characteristics of individual student long-term skill development when linked across programs and over time?

## Data and Methods

### Data Source and Access

LiteracyPro Systems contracts with numerous states and agencies to utilize LiteracyPro's LACES database for adult education programs' data entry and management and for state and NRS reporting. About 27 states are using LACES for their adult education data. For the purpose of this study, a Memorandum of Understanding (MOU) was developed between LiteracyPro and one state along with a second MOU between LiteracyPro and the author that allowed the author to conduct research using the state's de-identified LACES data.[3] Under the terms of the MOUs, the state is to remain anonymous and the data records accessed are to be de-identified. The MOUs also stipulate that student race/ethnicity is not to be reported.

The present study is based on de-identified LACES data records[4] from all Title II programs operating in the state between July 1, 2007, and June 30, 2019, comprising complete records for the 12 successive PYs 2007 through 2018.[5] The records analyzed contain data about students, registration, attendance, instruction, and assessment. Considerable effort was invested in organizing and cleaning these administrative data records using standard techniques (e.g., Goerge & Lee, 2002).[6]

For the present study, an active student is defined as a student with at least some hours of attendance in a Title II program. Students who register for but never attend a program are not active students and are excluded from the present study. There are 354,712 active students in the analytical data set.

LACES assigns unique internal student ID #s linked to program ID #s and program-assigned student ID #s. LiteracyPro de-duplicates its internal student ID #s within PYs so that single-year NRS reports contain unduplicated counts of students served. LiteracyPro does not typically de-duplicate across PYs, however, so individuals who enroll in multiple PYs may be assigned multiple internal student ID #s and thus appear as distinct students in the data. To view the full longitudinal extent of individual student records, the present study needed to de-duplicate students across PYs.

Prior to de-duplication, an important quality control step was taken to assure that the counts of students served in each PY matched the numbers the state reported to the NRS. The number of students in the analytical database with 12 or more instructional hours in a given PY was compared with the state-reported total number of "Participants" in NRS Table 1. The two numbers were identical for each of the PYs. In addition, the number of students in the analytical database with less than 12 instructional hours in PY 2018 and the total number of "Reportable Individuals" reported in NRS Table 2A for PY 2018, the only PY in the study for which Table 2A is available, were also identical.

3 Neither LiteracyPro nor the author received any compensation for conducting this research.

4 Thanks to David Miller, the founding CEO of LiteracyPro Systems, and the anonymous state's director of adult education for developing these MOUs and data access.

5 Thanks to Jim Rowe and Shannon Stangis of LiteracyPro Systems for assistance accessing and interpreting these data. Errors made, opinions expressed, and recommendations suggested are those of the author and not of LiteracyPro Systems.

6 Stata 17 software was used to manage and analyze all data.

## Analytical Methods

### *Participation Patterns*

Student records were de-duplicated (details of which are described in Appendix A). De-duplicated student records were linked across PYs and programs to describe numerous aspects of student-specific participation patterns expanded across time and programs. The basic participation data record contains instructional hours by dates that each student attended a specific class within a specific program under the auspices of a particular agency in the state. Programs were categorized as one of three types: ABE, ASE, or ESL. Instructional hours were specified as being in-person or distance as well as being led by a classroom teacher or a small-group tutor.

These student-specific participation records were analyzed and characterized in terms of:

- first PY of participation
- number of PYs in which participation occurred
- participation in multiple courses, programs, and types of programs
- class format (e.g., teacher-led classroom, tutor-led small group)
- mode of instruction (e.g., in-person, distance/remote)
- total hours of attendance across PYs
- total time span in days between first and last attendance dates
- breaks between periods of participation (i.e., gaps of 90+/180+/365+ days between successive attendance dates)

Students are grouped into cohorts according to the first PY of their participation. There are 12 cohorts of students whose participation started in the 12 PYs 2007–2008 through 2018–2019. The features of their participation patterns will be disaggregated and presented graphically by the first PY of a student's participation.

### *Skill Gains*

Programs measured skill development using many types of skill tests for placement and progress assessment. Student-specific assessment records in the study's database contained assessment date, type, form and level of test administered, scaled test score, and (for NRS-approved tests) the NRS Educational Functioning Level (EFL). The most widely used test types were the Tests of Adult Basic Education® (TABE) 9/10 series, especially the TABE Reading, Applied Math, and Math Computation (Math Comp.) assessments.[7] These assessment instruments were used throughout the 12-year study period.

To measure skill gains validly with these tests, only students having two or more assessments with psychometrically comparable test forms (e.g., TABE 9 Reading & TABE 10 Reading) were included in the analyses. For purposes of this study, a student's skill gain is defined as the difference between the scaled test scores of the first and final psychometrically comparable tests taken by the student.[8] Such measurements of skill gain are considered valid and were included in the analyses only if the final test form used had not been administered to the student within the preceding six months.[9] [10] For example, if a final TABE 10 Reading form had been preceded by a TABE 10 Reading form administered three months earlier, the skill gain would be invalid; if only TABE 9 Reading test(s) had been administered in the six months preceding the final TABE 10 Reading test, the skill gain would be considered valid.

For this study, each valid skill gain is associated with a measurement of both gain days and gain hours. Gain days are defined as the number of calendar days between a student's first and final test dates comprising the given skill gain. Note that the number of gain days can be less than the student's total time span of instruction. Gain hours are

7 More detailed descriptions of these TABE 9/10 assessments is available at https://tabetest.com/PDFs/TABE_9_10_Brochure.pdf

8 Although other methods of modeling skill development, such as linear growth modeling, were considered, those methods have requirements for multiple assessment points and data structure that only a small proportion of the student records would satisfy. Linear growth models, such as those used by Tighe et al. (2013), Reder (2014), and Yin et al. (2022), require at least three observation points per person. For the TABE 9/10 Reading, Applied Math, and Math Comp. skills, only 39.1%, 35.1%, and 33.7%, respectively, of the valid skill gain sequences contained three or more observations per student. It was preferable for the purposes of this study to include as many students as possible in the analyses of skill gain rather than estimating linear growth models for a small fraction of applicable students.

9 This is consistent with the test developer's psychometric specifications for TABE 9/10 (available from www.tabetest.com).

10 Placement tests and practice tests are not included in these analyses.

defined as the number of instructional hours the student attended between the first and final test dates comprising the given skill gain. Note that the number of gain hours can be less than the student's total instructional hours. Further, an individual student may (and often does) have different numbers of gain hours for each of the skill gains measured for that student.

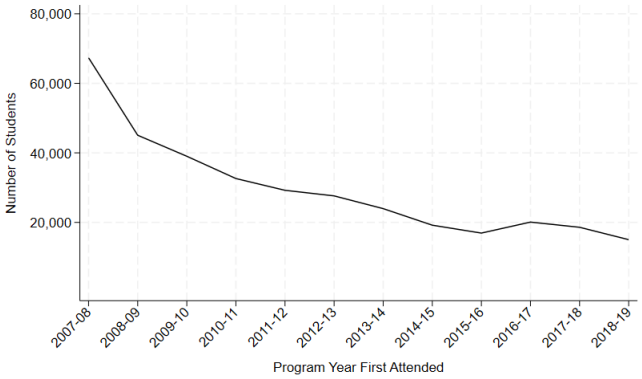
The second research question focuses on the relationship between students' long-term participation in adult education and their skill development. This focus is operationalized by asking, for each given skill, whether average skill gains rise linearly with increasing numbers of gain hours among students who participate in adult education over long periods of time. For the purposes of these analyses, a long-term skill gain is defined as having one year or longer of gain days (i.e., 365 or more gain days). This question is addressed graphically with plots of the average skill gain against the number of gain hours for the skill. Ordinary least squares (OLS) regression models are also fit to the data, predicting skill gain in terms of gain hours while controlling for student characteristics and initial test score. An important issue here is the extent to which such linear relationships, seen in short-term studies reviewed prior, are also evident for students whose skill gains are measured over long time periods. Addressing this question will clarify whether some students' extended time spans of participation in adult education encompass intervals of ongoing skill development rather than, for example, repeated unsuccessful attempts to improve fundamental skills.

# Results

## Student Cohorts and Characteristics

Discrete cohorts of active students were identified based on the first PY in which they attended a class. Figure 1 displays the number of students first attending in each of the 12 PYs, 2007–2008 through 2018–2019. The number of students shown in Figure 1 for a given PY is generally close to the official number the state reported to the NRS for the PY but differs in two respects. First, students with less than 12 instructional hours in a PY are included in the present study and shown in Figure 1 but are not included in NRS reports.[11] Second, because the present study de-duplicated students across PYs, the number of students shown in Figure 1 for a PY excludes a substantial number who participated in an earlier PY.

**FIGURE 1: Students First Attending Instruction in Given Program Years**




The steady decline in the cohort size from PY 2007 through PY 2018 reflects the steady decline in NRS-reported participants for both the state and the nation as a whole (Pickard, 2022). Overall, nearly equal numbers of male (49.7%) and female (50.3%) students participated, with the mix quite stable across the 12 PYs (Appendix B, Figure B1).

The ages of incoming adult education students range between 16 and 90, with an average of 31.2 and a median of 27. Female students are older on average (32.8) than male students (29.6). It appears that cohort ages dropped over time during WIA (PYs 2007–2014) and then stabilized during WIOA PYs 2015–2018 (Appendix B, Figure B2).

About one in eight (12.6%) of this state's adult education students are non-native speakers of English, a considerably lower proportion than reported by many other states. The mix of native and non-native English-speaking students is relatively stable over time (Appendix B, Figure B3). Nearly half (47.0%) of incoming adult education students are unemployed, 22.6% are employed, and 30.4% are not in the labor force. A higher percentage of incoming male students (27.6%) is employed than female students (17.6%). This mix of employment status is relatively stable over time (Appendix B, Figure B4).

11 In PY 2018–2019, states reported in NRS Table 2a the number of "Reportable Individuals" with less than 12 instructional hours, different from the "Participants" with 12 or more instructional hours reported in other tables.

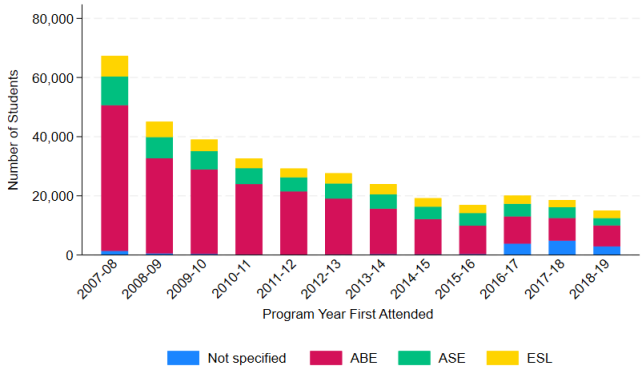
The administrative data do not include the educational background and learning goals of all incoming students. Overall, educational attainment data is available for 58.3% of incoming students. This percentage jumps up suddenly with changes in federal reporting requirements (Appendix B, Figure B5). Students with known prior educational attainment had an average of 10.9 years of prior education, with 57.7% having less than 12 years. Overall, learning goal data are specified for 68.5% of the students, dropping down precipitously with changes in federal reporting requirements (Appendix B, Figure B5).

## Participation Patterns

### *Program Types*

Figure 2 displays the number of students initially participating in the three program types (ESL, ABE, ASE) during the PY in which they first received instruction. Overall, about one in eight (12.2% of) adult education students participating in PY 2008 through PY 2019 initially participated in an ESL program, 1 in 3 (68.6%) in an ABE program, and one in five (22.2%) in an ASE program. A relatively small number (7.7%) of students initially participated in multiple types of programs. Note the height of each bar in Figure 2 is the total number of students shown first participating in the given PY in Figure 1. Figure 2 shows similar overall proportions of students having each entry program type. For most PY cohorts, only a small fraction of students had an entry program type that is Not Specified.[12]

## FIGURE 2: Number of Students Per Entry Program Type

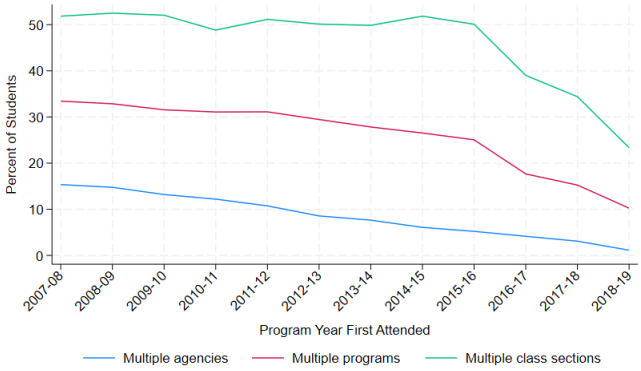



### *Multiple Instructional Contexts*

Many students participated in adult education programs offered by multiple agencies, in multiple programs offered by the same agency, and in multiple class sections within a given program. More than one in four (28.5% of) students participated in multiple programs; about one in three (36.7%) of these multi-program students participated in programs offered by multiple agencies. Among students participating in only a single program, more than one in four (27.9%) participated in multiple class sections of the program over time.

Figure 3 displays the percentages of students participating in adult education offered by multiple agencies, multiple programs, and multiple class sections for each PY cohort. Declining percentages over time of students participating in multiple programs and agencies are evident, as are right-censoring effects over the last few PYs of each curve. The declining percentages over time of multi-program and multi-agency students in part reflect the consolidation of adult education programs within the state across the PYs.

## FIGURE 3: Percent of Students by Learning Context




### *Instructional Format*

Figure 4 displays the mix of instructional formats in which students participated, plotted as a function of their initial program year of participation. The preponderance (91.2%) of students participated only in teacher-led classes. A much smaller number (6.7%) of students participated only in tutor-led small groups. An even smaller number (2.1%) of students participated in

12 For unknown reasons, there are a larger number of Not Specified program types in the last few PYs of the study.

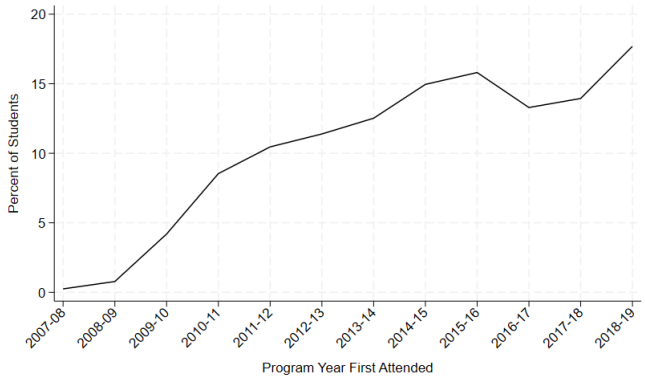
both instructional formats within their adult education. This overall mix is fairly stable across the PY cohorts. The mix of formats is roughly equal among male and female students as well as among older and younger students as well as among students with varying amounts of prior education. Non-native speakers of English, however, are much more likely than native speakers to participate in at least some tutor-led groups within their adult education.

## FIGURE 4: Percent of Students Per Instructional Format

### *Instructional Modality*

Figure 5 displays the percentage of adult education students taking some distance education as a function of their initial PY of instruction. Overall, nearly all (99.6%) had some in-person instruction over the course of their adult education, whereas only 9.4% participated in some distance instruction. As Figure 5 shows, distance instruction became more common over time as students, teachers, and programs increasingly used technology. For the PY 2007–2008 cohort, hardly any students took any distance education in their adult education career, whereas by PY 2018–2019, nearly one in five had taken some distance education. Overall, female, native English-speaking, younger, and less educated students were more likely to have participated in at least some distance education.

## FIGURE 5: Percent of Students Taking Some Distance Instruction

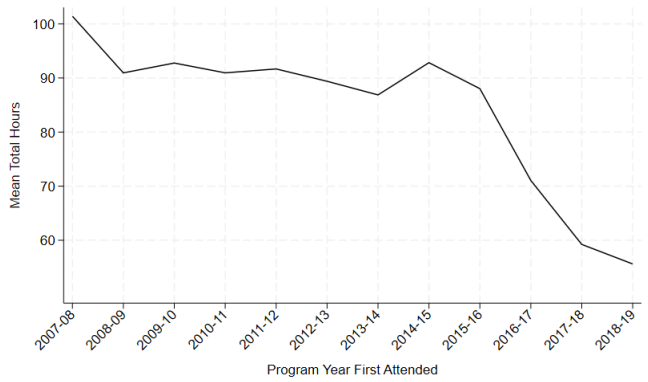



### *Amount of Instruction*

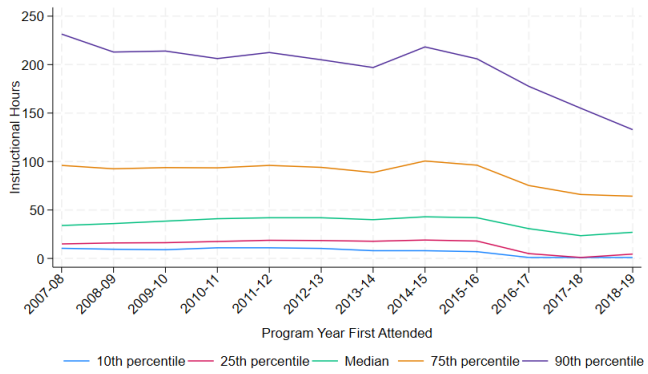
Overall, students averaged 88.5 total hours of adult education instruction with a median of 37 hours. One in four students attended 15 or less hours, while another one in four students attended 90 or more hours. Female students attend a few more hours on average (91.4) than male students (85.5). Non-native English-speaking students attended more hours on average (111.3) than native English-speaking students (85.2). Students aged 25 and above attended fewer total hours on average (82.0) than students aged under 25 (97.4). Students with 12 or more years of previous education averaged fewer hours (77.4) than students with less than 12 years of prior education (110.4).

Figures 6 and 7 show total instructional hours per student for each PY cohort. Figure 6 shows the mean number of total hours per student whereas Figure 7 illustrates the distribution of total hours per student, including the 10th, 25th, 50th (median), 75th, and 90th percentiles of total hours. The mean total hours per student declines across the PY cohorts, sharply declining over the final four. Because the means shown in Figure 6 are calculated across students with small numbers of hours as well as students with large numbers of hours, it is helpful to interpret these trends by also looking at the distributional information about total hours in Figure 7.

## FIGURE 6: Mean Instructional Hours Per Student




## FIGURE 7: Distribution of Total Instructional Hours Per Student




The sharp decline in the mean of total hours across the last few PY cohorts is again evident in the 75th and 90th percentile curves in Figure 7, suggesting that relatively fewer students starting in those last PYs had large numbers of total hours by the end of PY 2018–2019. Since large numbers of instructional hours are likely to have accumulated over multiple PYs, data from student cohorts of the last few PYs in the study does not include these instructional hours that may have occurred after the end of PY 2018–2019. The non-inclusion of these instructional hours in these late cohorts is an example of right-censoring of longitudinal data.

### *Timing and Duration of Instruction*

Two-thirds (67.9%) of students participated during only a single PY. One-third (32.1%) of students participated during two or more PYs. One in eight students (12.1%) participated during three or more PYs. Almost half (47.0%) of these three+ PY students were de-duplicates, suggesting their programs may not have been aware of their long-term participation pathways. This is further explored below in terms of the number of days individual students' instruction spans.

The time span of instruction is defined as the number of days elapsed between the first and last report of a student's attendance in adult education classes.[13] The time span between the start and end of a student's hours of attendance has a mean of 387 days and a median of 63 days. Nearly one in four students (23.5%) has a time span of zero. That is, all of the student's hours are reported within a single attendance report. The median total hours attended by these zero time span students is 12, meaning that half of them were not included in NRS reports under the 12-hour rule.

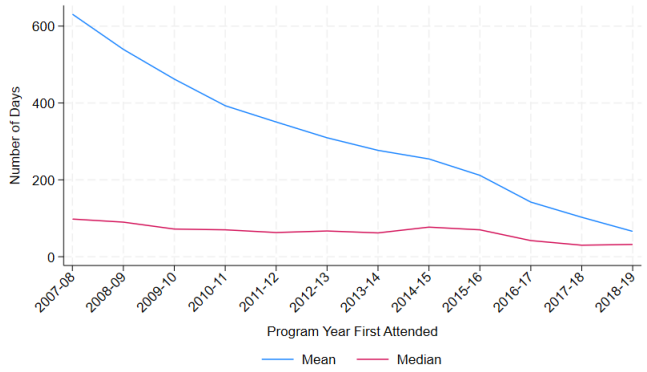
Many students' have longer time spans: 46.2% have spans of 90 days or more; 35.0% have spans of 180 days or more; 25.1% have spans of 365 days or more. The focus of the present study will be on these students having time spans of instruction of a year or more (i.e., 365 or more days). These students will be designated long-term students. Almost half (48.5%) of the long-term students have time spans of instruction of three years or longer. Almost half (42.2%) of the long-term students are de-duplicates, again suggesting programs may be unaware of many students' longer participation patterns in adult education.

Figures 8 and 9 display the distribution of students' time spans of participation, measured in days, for the cohorts beginning in each PY. The sharp decline of the mean time span seen in Figure 8, coupled with the slight decline evident in the corresponding median spans, suggests that right-censoring is limiting the observation of longer time spans. This interpretation is confirmed by Figure 9, in which steady declines in the time spans observed in the 75th and 90th percentile curves but not in the 10th, 25th, and 50th

13 Programs submitted attendance reports on a daily, weekly, or occasionally longer-term basis.

percentile curves. Female, non-native English-speaking students, older students, and students with less prior education tended to have longer time spans of participation.

## FIGURE 8: Time Span of Instruction




## FIGURE 9: Time Span of Instruction

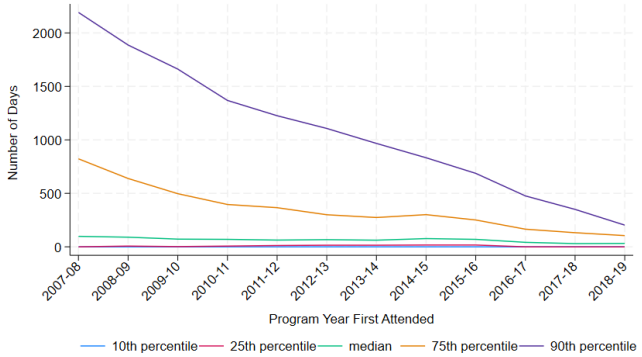
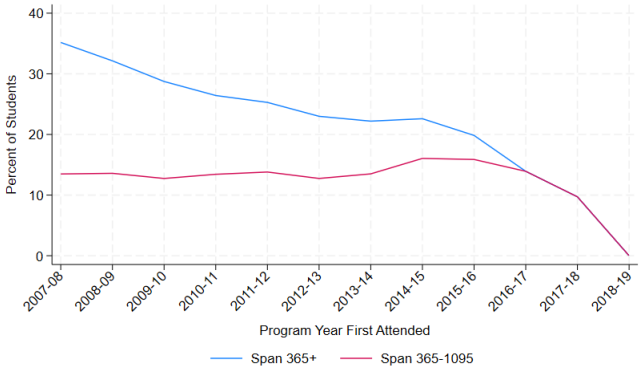



Figure 10 displays changes across the PY cohorts in the prevalence of students participating in adult education over relatively longer time spans. The red line displays the percentage of students having time spans of 365 or more days. Three out of four (75.0%) students with time spans of 365+ days are multi-program students. The steady decline in the observed percentage across PY cohorts could be due to increasing right-censoring of longer time spans. To address this question, the red line in the figure displays the percentage of each PY cohort having time spans between 365–1,095 days (i.e., this differs from the blue line in that time spans longer than three ears are excluded from the calculation). The red line shows no major changes across PYs until the final two PYs (when right censoring takes place), reflecting a steady percentage of incoming adult education students who participated over these relatively longer time spans.

## FIGURE 10: Long Time Spans of Instruction




Longer time spans of instruction are widespread among varying types of students. Similar percentages of female and male students, 26.2% and 23.9%, respectively, have time spans of at least a year. The percentage of students with time spans of a year or longer is slightly higher among non-native English speakers (29.1%) than among native English speakers (24.5%). The average age at program entry of students who exhibit these longer time spans is 29.0, younger than the average age (31.9) of students who do not exhibit these longer time spans. The average years of prior education is similar among students exhibiting longer time spans (10.5) and among students not exhibiting them (11.0).

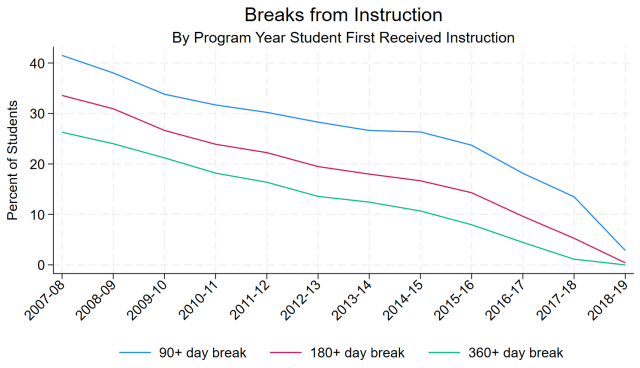
These extended participation trajectories in adult education occur more frequently among students who enter with a specific goal in their records; 29.2% and 16.0% of students with or without a recorded goal, respectively, exhibit time spans of instruction longer than a year. About one in four students (28.9%) with an education goal (e.g., GED® credential, postsecondary transition) have time spans of 365 days or longer. About one in three students (35.4%) with an economic goal (e.g., getting a job or getting a better job) exhibit these extended participation trajectories of 365 days or more. Only one in five (19.9%) of the long-term students ever take a GED test, another indication that long-term participation in adult education may be motivated by a broader set of student goals than those currently emphasized by the programs.[14]

14 The GED was the only high school equivalency in the state during the time period of this study.

### *Breaks in Participation*

Students participating over long time spans often take breaks from participation. That is, they stop participation, pausing for a period of time, and then resuming their adult education. Taking these breaks, sometimes called "stopping out," can occur within a given program or across programs.[15] Figure 11 displays the percentages of students exhibiting breaks of 90 or more days, 180 or more days, and 365 or more days in length. As seen above for the longer time spans of participation, de-duplication makes these longer breaks visible in many more student records. For example, 38.6%, 45.4%, and 50.8% of the students with 90+, 180+, and 365+ day breaks between instruction are de-duplicates, respectively. Right-censoring is again evident in these curves in Figure 11.

## FIGURE 11: Breaks From Instruction




### *Summary of Participation Patterns*

The cross-PY, de-duplicated data display longer and more varied participation trajectories than those that can be seen in single PY reports. The longer participation trajectories—often encompassing multiple programs, periods of participation, and breaks from participation—are consistent with research on program retention and student persistence in adult education, as reviewed above. These expanded trajectories of participation in adult education include increased hours, more breaks from and discrete periods of participation, and more program transitions. The expanded participation trajectories in adult education are evident among diverse students, including those who enter with specific education or economic goals and students engaged and students not engaged in high school equivalency testing.

In the expanded participation trajectories, non-native English speakers accumulate more instructional hours than native speakers, consistent with findings of research involving shorter spans of participation (Comings et al., 1999; Greenberg et al., 2013). A new finding is that non-native speakers are more likely to participate in tutor-led groups as opposed to teacher-led classrooms. Another interesting detail of the participation patterns is that younger learners tend to accumulate more instructional hours than older learners. Although this appears to contrast with some previous research that found older learners tend to accumulate more instructional hours than younger learners, the previous research is based on short-term participation. In the current study, this contrast varies between short-term and long-term spans of participation. Within long-term participation spans, older learners tend to accumulate more instructional hours whereas in short-term participation spans, younger learners tend to accumulate more instructional hours.

Given the frequency of these expanded participation trajectories among adult education students, it is important to determine whether skill development occurs over the longer time spans of participation. It is possible that repeated periods of participation do not all contribute to skill development, which might be the case if breaks from instruction, for example, set learning back or reset student learning such that overall skill gains do not occur.

### Skill Gains

Analyses of skill gains were conducted separately for each of the three skills examined: TABE 9/10 Reading, Applied Math, and Math Comp. Table B1 (found in Appendix B) displays, for each of these three skills, the number of students with valid skill gains measured, their

15 NRS Table 4, starting in PY 2017, counts 90+ day breaks within a single PY as distinct "Periods of Participation" (POPs). Multiple POPs across PYs, however, are not identified within NRS reports.

mean initial test score, and mean skill gain.[16] In addition, the table displays the mean and median gain hours and gain days associated with the measured skill gains. Finally, the table displays the percentage of these students exhibiting long-term skill development, comprised of at least a year of gain days.

Almost one in three (31.8%) of the 354,712 active students had validly measured gains on one or more of these skills.[17] Less than half (44.5%) of these students with a measured skill gain had skill gains measured on more than one of the skills. Almost two in three (63.3%) of the students with a measured skill gain had a Reading skill gain, whereas more than three in four (76.6%) of the students with a measured skill gain had an Applied Math and/or Math Comp. skill gain measured. Two in five (40.0%) of the students with a measured skill gain had both a Reading and a math skill gain measured.[18]

Analyses of skill gains for students with known levels of prior educational attainment involves much smaller numbers of students because of the aforementioned lack of information about prior education in many students' adult education records. Table B1 in Appendix B summarizes the corresponding skill gain characteristics for students with known levels of prior educational attainment. Note the close similarity of the characteristics of the skill gains shown in Tables 1 and B1. Because the skill gain characteristics of students are similar regardless of whether information exists about their prior education, the subsequent analyses will include all students; separate analyses for students with known prior educational attainment are presented in Appendix B.

## TABLE 1: Skill Gain Characteristics for Three TABE 9/10 Skills

| | Reading | Applied Math | Math Comp. |
|---|---|---|---|
| **Number of students** | 71,490 | 51,717 | 57,988 |
| **% female** | 49% | 48% | 49% |
| **Mean age** | 28 | 28 | 30 |
| **% non-native English speaker** | 2% | 1% | 1% |
| **Mean initial test score** | 532 | 518 | 475 |
| **Mean skill gain** | 20 | 24 | 31 |
| **Mean gain hours** | 98 | 100 | 76 |
| **Median gain hours** | 50 | 49 | 44 |
| **Mean gain days** | 713 | 605 | 510 |
| **Median gain days** | 372 | 310 | 184 |
| **% with gain days > 365** | 51% | 46% | 38% |

The primary focus here on skill development over relatively large time spans calls for analyses of skill gains over sufficiently long intervals of time between the first and final assessments of a given skill, i.e., a sufficiently large number of gain days for the skill being measured. The minimum gain days in the subsequent analyses is 365 days, meaning at least a year between the first and final assessment of a given skill (Reading, Applied Math, or Math Comp.). Table 2 displays some descriptive statistics for skill gains meeting these minimum gain day requirements.

16 Although it is important in analyses of skill gains to use the scaled test scores, NRS reporting collapses scaled test scores into pre-defined discrete EFLs. NRS reports numbers of students entering a program at given EFLs and numbers who advance one or more EFLs while in the program. For example, Appendix B Figure B6 displays the number of students entering programs at the six defined EFLs for TABE 9/10 Reading. Over their extended participation patterns, over half (56.5%) of the students advanced from their initial Reading EFL to a higher one by their final assessment (excluding students who started in the highest EFL).

17 The percentages of non-native speakers among students with these measured TABE 9/10 skill gains are much smaller than the 12.2% percentage of non-native speakers among all active students. This is because almost all of the non-native English-speaking students had their progress measured with BEST tests rather than with TABE tests.

18 A student with validly measured gains on more than one skill does not necessarily have the same number of gain hours or gain days for each of those skills. The alignment of gain hours across skills, for example, depends on the timing of the administration of the first and final tests for specific skills.

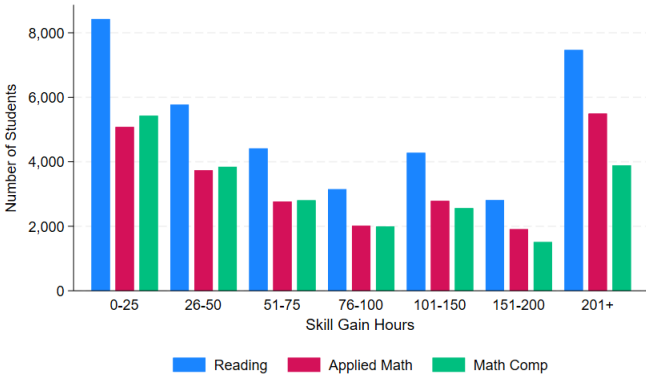
## TABLE 2: Skill Gain Characteristics for Three TABE 9/10 Skills of at Least 365 Gain Days

| | Reading | Applied Math | Math Comp. |
|---|---|---|---|
| Number of students | 36,146 | 23,651 | 21,929 |
| % female | 49% | 50% | 49% |
| Mean age | 26 | 26 | 28 |
| % non-native English speaker | 2% | 1% | 1% |
| Mean initial test score | 530 | 512 | 467 |
| Mean skill gain | 18 | 21 | 21 |
| Mean gain hours | 138 | 150 | 122 |
| Median gain hours | 72 | 78 | 64 |

In general, characteristics of students and their skill gains are similar regardless of whether we look only at students with skill gains of at least 365 gain days. Comparing Tables 1 and 2, a few small differences are apparent. Students with skill gains measured over at least a year's time tend to be a couple years younger at the time they entered adult education than students having any measured skill gain. Students with the longer measured skill gain periods tend to have lower initial test scores, smaller skill gains, and attend larger numbers of instructional hours within their skill gain intervals. Corresponding descriptive statistics for students having known levels of prior education are displayed in Table B2 in Appendix B.

Figure 12 exhibits the distribution of skill gain hours for students with long intervals of skill gain days. The blue bars display the number of students attending various amounts of instructional hours within their Reading skill gains. The red and green bars display the corresponding data for the Applied Math and Math Comp. skill gains, respectively.[19] For each skill, the distribution has the same general shape, with relatively large numbers of students attending the smallest category of gain hours, large numbers attending the largest category of gain hours, and smaller numbers of students attending intermediate amounts of instruction.[20]

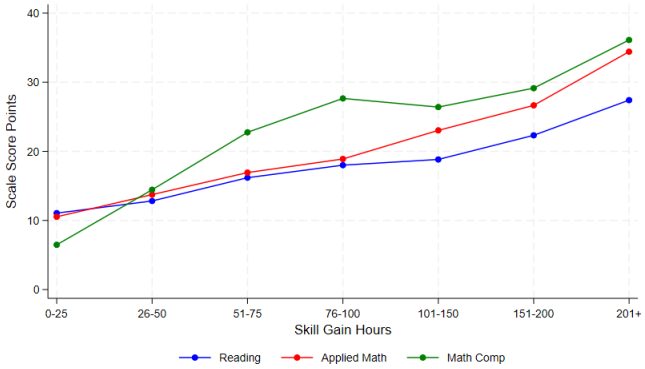
## FIGURE 12: Gain Hours for TABE 9/10 Reading, Applied Math, and Math Comp. Skill Gains




**Note.** Limited to skill gains of at least 365 gain days.

Figure 13 displays the mean skill gains for students in these gain hour categories for the TABE 9/10 skills measured: the blue curve for Reading, the red curve for Applied Math, and the green curve for Math Comp. skills. As before, the focus on long-term skill growth limits these analyses to skill gains comprised of at least a year of gain days. For each of the skills, the average skill gain increases systematically with increasing numbers of instructional hours within the skill gain's measurement interval. The statistical significance of the linear component of this apparent trend over gain hours is explored below with OLS regression models.

## FIGURE 13: Skill Gains by Gain Hours for TABE 9/10 Reading, Applied Math, and Math Comp.




**Note.** Limited to skill gains of at least 365 gain days.

19 Although it might be helpful to distinguish between gain hours of instruction that focus on and gain hours that do not focus on the particular skill in question (e.g., Reading), the administrative data does not contain enough systematic information about instructional content to make this feasible. For all but the final couple PYs, programs were required to pre-select particular skill assessments to use for measuring student progress, so that the very existence of a particular skill gain reflects the program's expectation that the instructional content the student would receive would be relevant to that skill.

20 In Appendix B, Figure B7 displays the corresponding skill gain hours data for students who reported prior levels of education to the NRS.

OLS regression models were estimated separately for each of the three skill gains, predicting skill gains in terms of initial test score, gain hours, and student characteristics (gender, age, and native language status). Results of fitting these regression models to the three skill gains are shown in Table 3. The most important result is the statistically significant, positive coefficient for Gain Hours in each regression equation with other variables controlled, confirming the apparent trend of increasing skill gains across gain hours seen in Figure 13.

## TABLE 3: Regression Models of Skill Gains of at Least 365 Gain Days for Three TABE 9/10 Skills

| Variables | Reading | Applied Math | Math Comp. |
|---|---|---|---|
| **Initial test score** | -0.413*** | -0.403*** | -0.523*** |
| | (0.00398) | (0.00515) | (0.00607) |
| **Gain hours** | 0.00322** | 0.0153*** | 0.0228*** |
| | (0.00145) | (0.00172) | (0.00234) |
| **Age** | -0.549*** | -0.506*** | -0.150*** |
| | (0.0245) | (0.0329) | (0.0319) |
| **Female** | 0.459 | -3.067*** | -2.764*** |
| | (0.557) | (0.694) | (0.786) |
| **Non-native speaker** | -3.114 | 6.755** | 7.031* |
| | (1.943) | (2.941) | (3.602) |
| **Constant** | 250.9*** | 239.5*** | 268.1*** |
| | (2.558) | (2.933) | (3.094) |
| **Observations** | 36,128 | 23,640 | 21,912 |
| **R-squared** | 0.240 | 0.222 | 0.266 |

**Note.** Standard errors in parentheses.
*** p < .01. ** p < .05. * p < .1.

Table 3 also shows, for each of the three skills, statistically significant larger skill gains for students who enter with lower test scores as well as for younger students. Female students have statistically significant lower skill gains for Applied Math and Math Comp. but statistically equivalent skill gains for Reading. Students who are non-native English speakers have statistically significant larger skill gains for Applied Math and Math Comp. but statistically equivalent skill gains for Reading.

Two additional analyses explore the generalizability of the key result that skill gains, over long periods of instruction (gain days, i.e.), are positively related to the number of instructional hours. The first analysis adds the student's prior education to the regression models of skill gains. The second analysis considers a broader range of skill gains, namely those comprised of at least 90 gain days rather than just those comprised of at least 365 gain days.

In the first analysis, similar results are found when prior education is included in the regression models (albeit with a much smaller number of observations). In Appendix B, Table B2 provides descriptive statistics for the student populations for whom information about prior education is available. Figures B7 and B8 display the distribution of gain hours and the mean skill gains as a function of gain hours, respectively, for the three measured skills. Table B3 shows the results from the OLS regression models for each skill that include prior education attainment as an independent variable. The key finding is replicated; skill gains remain positively related to gain hours even with prior educational attainment statistically controlled along with other student characteristics.

In line with previous research (e.g., Reder et al., 2020), the current study finds age to be negatively related to both literacy and numeracy gains, with younger adults averaging larger gains. This trend is summarized by the statistically significant negative coefficient of age in the multivariate regression models predicting skill gains. New findings here are that non-native speakers have significantly larger long-term gains in numeracy skills (but statistically equivalent gains in literacy), and female students have significantly smaller long-term gains in numeracy (but statistically equivalent gains in literacy).

Although the primary focus here is on basic skill development over long time periods of instruction lasting at least a year, it is important to know whether the patterns of skill growth observed over these longer periods also occur when shorter periods are included as well. This question is examined by replicating the analysis of skill gains measured over at least a year of gain days with a parallel analysis of skill gains measured over 90 days or more. Table B4 in Appendix B presents the descriptive statistics for this analysis. Figures B9 and B10 display the distribution of gain hours and the mean skill gains as a function of gain hours, respectively, for skill gains comprised of at least 90 gain days. Table B5 displays the fit of these data to the regression models predicting skill gains from initial test scores, gain hours, and student

characteristics. Table B5 shows, for Reading, Applied Math, and Math Comp., that the statistically significant positive effects of gain hours on skill gains are replicated for the temporally broadened set of skill gains comprised of 90 gain days or more.

## Discussion

### Summary

After linking individual student records together across multiple PYs and programs, the present study identified 354,712 unique adult education students who had attended one or more classes in the state during the 12-year period PY 2007–PY 2018. Nearly one in four students (23.5%) had a zero time span of participation, meaning all instructional hours were reported in a single attendance report. Another one in four students (25.0%) participated over a year or longer. Almost half (48.5%) of these long-term students participated over three or more years.

The present study focuses on these long-term individual participation patterns that were frequently observed to encompass multiple programs, periods of participation, and breaks from participation. Although these long-term participation patterns are consistent with research on program retention and student persistence in adult education, they are not well-captured in single-year NRS or state reporting. A large number (42.1%) of these extended participation patterns are not readily identified within program, agency, or state student-record systems, being identified in the present study only through de-duplication of individual student records across PYs and programs.

As found in short-term research (Comings et al., 1999; Greenberg et al., 2013), these longer-term participation patterns show that non-native English speakers accumulate more instructional hours than native speakers. A new finding is that non-native speakers are more likely to participate in tutor-led groups as opposed to teacher-led classrooms. Another interesting detail of the participation patterns is that younger learners tend to accumulate more instructional hours than older learners. Although this appears to contrast with some previous research that found older learners tend to accumulate more instructional hours than younger learners, the previous research is based on short-term participation. In the current study, this contrast varies between short-term and long-term spans of participation. Within long-term participation spans, older learners tend to accumulate more instructional hours whereas in short-term participation spans, younger learners tend to accumulate more instructional hours.

An important research question in the current study is the extent to which skill development is observed over long intervals between the first and final assessments of a foundational skill. It is possible, of course, that with the frequent breaks in attendance and program changes within long periods of participation and assessment, students may not show cumulative skill gains related to the total instructional hours they attended as some previous research has found for shorter intervals (e.g., Condelli et al., 2009). This question was explored in the present study by examining the relationship between measured skill gains and total instructional hours (termed "gain hours") attended between the initial and final assessment of the skill. For each of three skills examined (TABE 9/10 Reading, Applied Math, and Math Comp.), significantly larger skill gains were observed for increasing gain hours over the extended gain intervals. This long-term systematic skill growth over increasing instructional hours is evident both in graphical displays of these relationships and in statistical regression models of skill gains in relation to gain hours.

### Implications

The steady growth of basic skills over long-term participation trajectories is not easily identified, reported, or incentivized by an adult education system focused on single program-year accountability. Although largely unrecognized, these long-term trajectories of participation and learning co-exist with the shorter-term "pipeline" skill development trajectories that are emphasized in the current reporting, evaluation, and funding of adult education. Results of the current study demonstrate a major misalignment between the short-term outcomes that programs are accountable for and the long-term outcomes that they actually produce. States, programs, and advocates of adult foundational education can thus benefit from using longitudinally analyzed administrative data across program years. For the same reason, continuous program improvement efforts will likely be more effective using long-term rather than short-term skill gains as criterion measures.

Increased awareness, policy, and programmatic support and funding for the widespread long-term skill development observed in the current study is needed from adult education, government, and employers to better address the nation's skill development needs. In addition to the ongoing advocacy for increased funding for programs supporting relatively short-term focused adult education and skill growth, there is need to better understand and advocate for the role of adult education in supporting lifelong skill development that helps individuals navigate both short-term employment and education goals as well as broader types of lifelong and life-wide learning (Reder, 2020).

There are several ways to increase support for lifelong learning of foundational skills. States can improve their tracking of adult education students across time and programs. Shared access to student-centered records across programs would be helpful. These shared records ideally could include student goals, descriptions of course content taken, skill assessments, and other student outcome measures. In implementing such data systems, of course, due attention must be given to maintaining confidentiality and privacy. It would also help to have better quality standards and more resources to provide training for local data entry and management of student-centered administrative databases. Improvements in these areas will help states strengthen their tracking and evaluation of student participation and learning across time and programs. Better state tracking and awareness of lifelong skill development is essential for improving programmatic support for lifelong learning in adult education.

Longitudinal evaluations of program impact on skill growth and other student outcomes that are not limited to a single PY need to be developed and implemented to follow lifelong skill development. Whether such evaluations should be based on administrative data from all programs and students or on a richer set of measures collected from a sample of programs and students should be carefully considered.

## Limitations

Numerous limitations were encountered in working with the state's administrative adult education data to address the research questions of this study. The lack of systematic data about the content of instruction that students attended, students' goals in adult education, their reasons for stopping and re-entering instruction, and their education and employment outcomes limits what can be learned from the administrative data. Other states may have administrative adult education data with fewer or different limitations. Some states' administrative adult education data with which the author is familiar have more systematic information about the content of instruction, for example. Other states may have comprehensive linkages between adult education student records and employment and postsecondary education records.

Although the author expects the principal findings of the study to apply in many other states, caution is warranted in generalizing the findings of this study from the one state whose administrative adult education data was analyzed to the adult education systems in other states. Specific quantitative results will of course vary across states that have demographically different populations of adult education students. One important difference between the state studied and other states is the relatively low percentage of non-native speakers in the state's adult education population. Future research with administrative data from other states would be very helpful to extend the findings of this study.

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# Appendix A

## De-Duplication of Student Records

The de-identified student records in the analytical database omitted personal identifying information (PII). Several PII fields were included in non-reversible hash-coded format for de-duplication purposes: name and date-of-birth (available for all students) and social security number. The non-reversible hash coding of these fields completely masked these PII fields while allowing them to be matched for de-duplication.[21]

Student records with different internal student ID #s were de-duplicated (i.e., re-assigned to the same internal student ID #) if their hash-coded PII fields matched in one of two ways: their date-of-birth was identical and either (1) their hash-coded SSNs matched (if they had SSNs) or (2) their hash-coded names matched (if they did not have SSNs).[22] Overall, 63,573 (17.9%) of the 354,712 active students in the database were de-duplicated.

De-duplication occurred more often among students who participated in multiple PYs: 36.9% of students were de-duplicated who participated in more than one PY versus 17.7% of students who participated in only a single PY. De-duplication also occurred more often among students who participated in multiple programs: 36.4% of students who participated in multiple programs were de-duplicated versus 6.9% of students who participated only in a single program. The de-duplication rate was much higher (46.1% vs. 15.7%) among individual students who participated in more than one type (ESL, ABE, ASE) of adult education. Students who participate in programs offered by multiple agencies are particularly noteworthy in this regard; all but three of these 41,590 multi-agency students were de-duplicated.

These patterns suggest that student duplication (i.e., the same individual linked to multiple student ID #s within adult education records) occurred more frequently when students participated in multiple PYs and/or multiple programs over time. Nearly half (48.8%) of students who participated both in multiple programs and multiple PYs were de-duplicated.

The overall de-duplication rate declines substantially across PYs (Figure A1), suggesting that the state's tracking of students and linkage of their records across PYs and programs has improved over time. The de-duplication rate among multi-program students has also substantially declined over time (Figure A2), again suggesting improvement in the state's tracking of students across adult education programs.

**FIGURE A1: De-Duplication of Students with Various Time Spans of Participation**

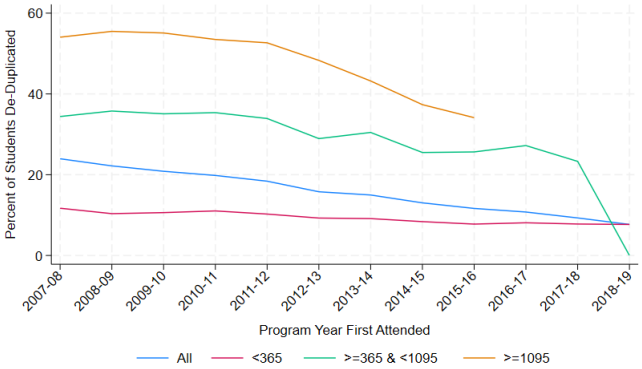
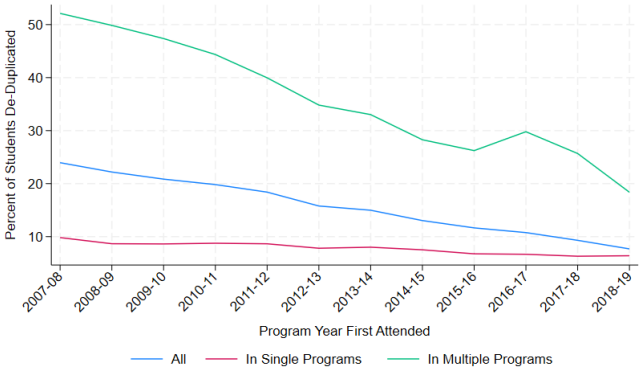



**FIGURE A2: De-Duplication of Students in Single or Multiple Programs**




These variations in de-duplication rates can help us understand the circumstances in which adult education students' extended participation has not been well tracked by the adult education system and suggest ways to improve tracking and program support for those students.

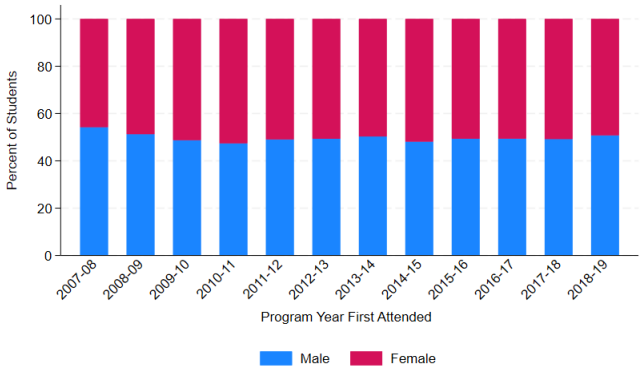
21 Thanks to Jim Rowe of LiteracyPro Systems for suggesting and facilitating this use of irreversible hash-coding.

22 Prior to de-duplication, 78% of the active student records had SSNs.

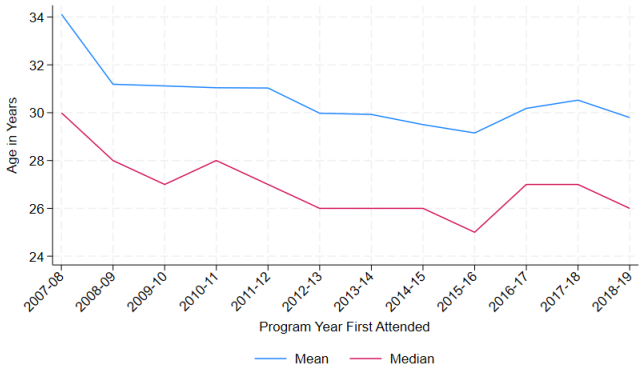
# Appendix B

## Participant Data

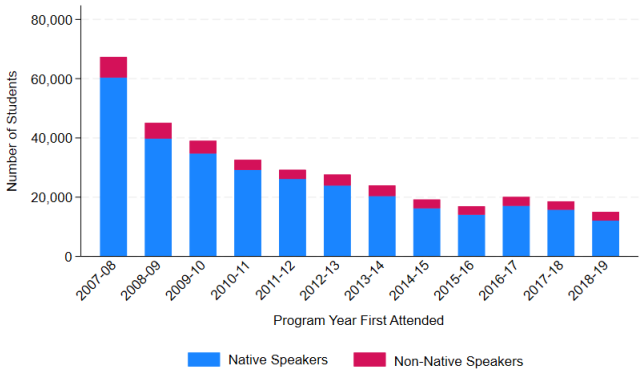
### FIGURE B1: Gender Mix of Students



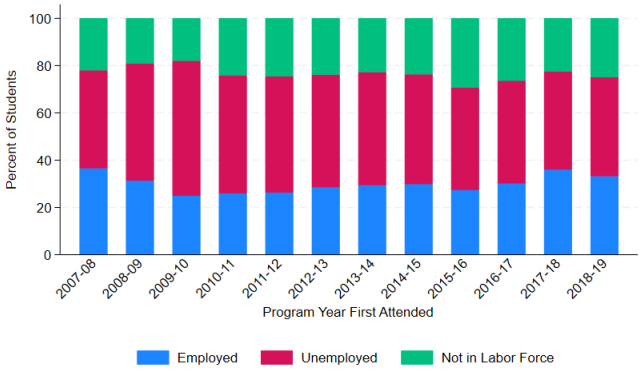

### FIGURE B2: Mean and Median Age of Incoming Students



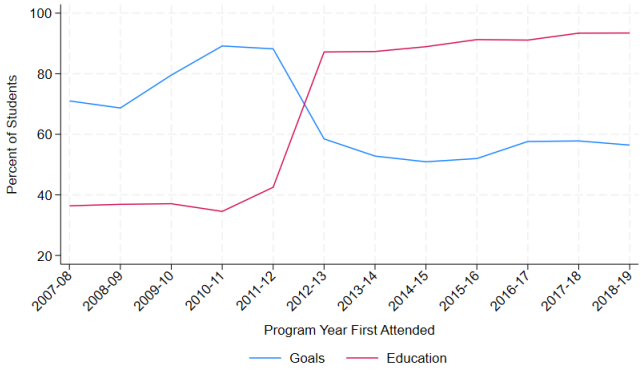

### FIGURE B3: Native and Non-Native English-Speaking Students




### FIGURE B4: Employment Status of Incoming Students



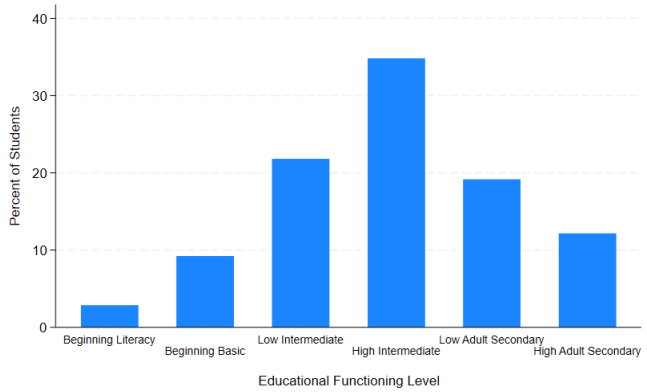

### FIGURE B5: Availability of Information About Goals and Prior Education of Incoming Students




### TABLE B1: Skill Gain Characteristics for Three TABE 9/10 Skills

| | Reading | Applied Math | Math Comp. |
|---|---|---|---|
| Number of students | 44,220 | 23,548 | 33,836 |
| % female | 51% | 50% | 51% |
| Mean age | 28 | 28 | 30 |
| % non-native English speaker | 2% | 1% | 1% |
| Mean years of prior education | 11 | 10 | 11 |
| Mean initial test score | 533 | 519 | 477 |
| Mean skill gain | 20 | 24 | 31 |
| Mean gain hours | 100 | 102 | 82 |
| Median gain hours | 51 | 50 | 47 |
| Mean gain days | 720 | 587 | 533 |
| Median gain days | 379 | 305 | 195 |
| % with gain days > 365 | 51% | 45% | 39% |

## FIGURE B6: Initial Educational Functioning Levels (EFLs) for TABE 9/10 Reading

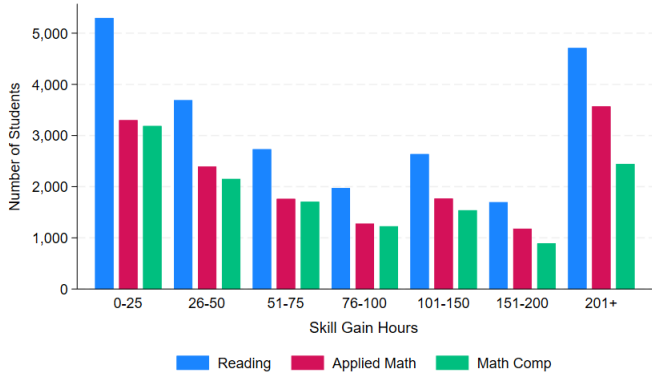



## TABLE B2: Skill Gain Characteristics for Three TABE 9/10 Skills Among Students with Known Prior Education

| | Reading | Applied Math | Math Comp. |
|---|---|---|---|
| **Number of students** | 22,746 | 15,252 | 13,153 |
| **% female** | 54% | 54% | 54% |
| **Mean age** | 26 | 26 | 28 |
| **% non-native English speaker** | 2% | 2% | 1% |
| **Mean years of prior education** | 10 | 10 | 10 |
| **Mean initial test score** | 531 | 513 | 466 |
| **Mean skill gain** | 18 | 21 | 21 |
| **Mean gain hours** | 139 | 152 | 127 |
| **Median gain hours** | 72 | 78 | 68 |

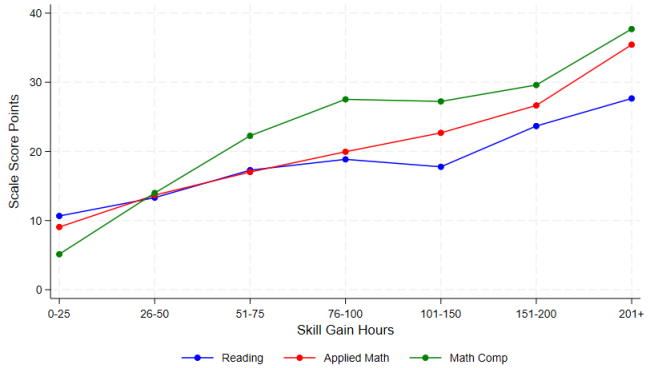
**Note.** Limited to skill gains of at least 365 days.

## FIGURE B7: Gain Hours for TABE 9/10 Reading, Applied Math, and Math Comp.




**Note.** Limited to students with known levels of prior education and skill gains of at least 365 gain days.

## FIGURE B8: Skill Gains by Gain Hours for TABE 9/10 Reading, Applied Math, and Math Comp.




**Note.** Limited to students with known levels of prior education and skill gains of at least 365 gain days.

## TABLE B3: Regression Models of Skill Gains

| Variables | Reading | Applied Math | Math Comp |
|---|---|---|---|
| Initial test score | -0.403*** | -0.360*** | -0.500*** |
| | (0.00498) | (0.00626) | (0.00774) |
| Gain hours | 0.00300* | 0.0196*** | 0.0250*** |
| | (0.00172) | (0.00203) | (0.00285) |
| Age | -0.515*** | -0.478*** | -0.161*** |
| | (0.0296) | (0.0385) | (0.0410) |
| Female | 0.473 | -2.691*** | -2.024** |
| | (0.679) | (0.833) | (0.993) |
| Non-native speaker | -4.136* | 7.601** | 5.721 |
| | (2.232) | (3.260) | (4.275) |
| Prior education | 1.421*** | 0.474 | 2.234*** |
| | (0.221) | (0.298) | (0.330) |
| Constant | 230.3*** | 211.1*** | 233.4*** |
| | (3.481) | (4.522) | (4.954) |
| Observations | 22,657 | 15,183 | 13,093 |
| R-squared | 0.235 | 0.200 | 0.256 |

**Note.** Gains of at least 365 gain days for TABE 9/10 Reading, Applied Math, and Math Comp. among students with known levels of prior education. Standard errors in parentheses.

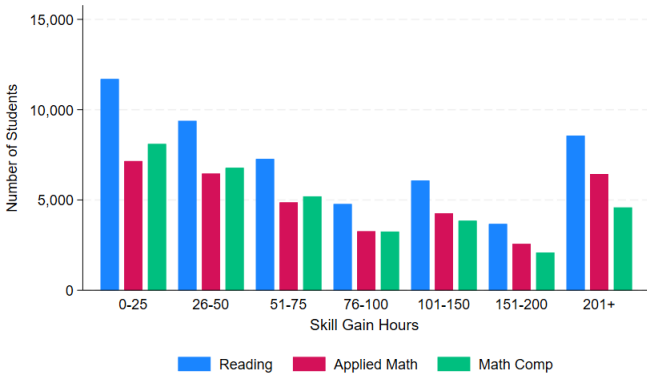
*** p < .01. ** p < .05. * p < .1.

## TABLE B4: Skill Gain Characteristics for Three TABE 9/10 Skills

| | Reading | Applied Math | Math Comp. |
|---|---|---|---|
| Number of students | 51,471 | 35,022 | 33,890 |
| % female | 49% | 50% | 49% |
| Mean age | 27 | 26 | 29 |
| % non-native English speaker | 2% | 2% | 2% |
| Mean initial test score | 527 | 513 | 467 |
| Mean skill gain | 18 | 22 | 24 |
| Mean gain hours | 121 | 129 | 105 |
| Median gain hours | 65 | 69 | 59 |

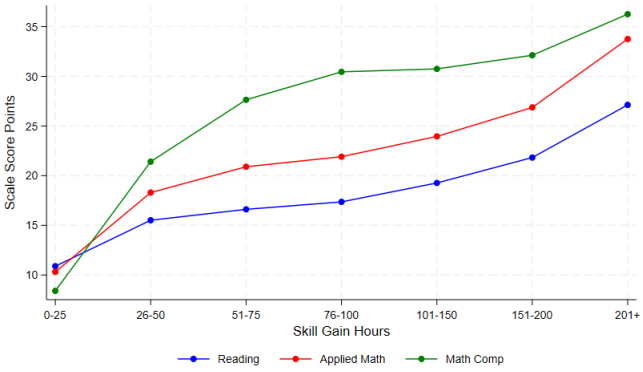
**Note.** For skill gains of at least 90 gain days.

## FIGURE B9: Gain Hours for TABE 9/10 Reading, Applied Math, and Math Comp.




**Note.** Limited to skill gains of at least 90 gain days.

## FIGURE B10: Skill Gains for TABE 9/10 Reading, Applied Math, and Math Comp.




**Note.** Limited to skill gains of at least 90 gain days.

## TABLE B5: Regression Models for TABE 9/10 Reading, Applied Math, and Math Comp.

| Variables | Reading | Applied Math | Math Comp |
|---|---|---|---|
| Initial test score | -0.392*** | -0.391*** | -0.485*** |
| | (0.00325) | (0.00419) | (0.00473) |
| Gain hours | 0.00506*** | 0.0132*** | 0.0219*** |
| | (0.00136) | (0.00160) | (0.00217) |
| Age | -0.448*** | -0.382*** | -0.121*** |
| | (0.0193) | (0.0256) | (0.0246) |
| Female | 1.107** | -2.186*** | -2.809*** |
| | (0.466) | (0.569) | (0.631) |
| Non-native speaker | -4.383*** | 5.174** | 9.780*** |
| | (1.491) | (2.316) | (2.573) |
| Constant | 236.0*** | 231.2*** | 252.6*** |
| | (1.908) | (2.386) | (2.435) |
| Observations | 51,332 | 34,921 | 33,747 |
| R-squared | 0.227 | 0.210 | 0.246 |

**Note.** Skill gains of at least 90 gain days. Standard errors in parentheses.
*** p < .01. ** p < .05. * p < .1.