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Relationships Between School, Teacher, and Feature Characteristics and Teachers’ Access to Features Within Digital Curriculum Resources for Mathematics Instruction

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RELATIONSHIPS BETWEEN SCHOOL, TEACHER, AND FEATURE
CHARACTERISTICS AND TEACHERS’ ACCESS TO FEATURES
WITHIN DIGITAL CURRICULUM RESOURCES
FOR MATHEMATICS INSTRUCTION

by

M. Jill Harmon

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

In

Education
(Mathematics Education and Leadership)

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2023
ABSTRACT

Relationships Between School, Teacher, and Feature Characteristics and Teachers’ Access to Features Within Digital Curriculum Resources for Mathematics Instruction

by

M. Jill Harmon, Doctor of Philosophy

Utah State University, 2023

Major Professor: Patricia Moyer-Packenham, Ph.D.
Department: School of Teacher Education and Leadership

In 2019, RAND Corporation asked teachers which digital programs they used. This dissertation study expanded on this research by exploring the features contained in these programs. The purpose of this study was to investigate the relationships between teachers’ access to features and school, teacher, and feature characteristics. This study had two research questions: (1) Which of the six features are most commonly present within digital mathematics curriculum resources that teachers report using often? What percentages of teachers have access to each of the chosen features? (2) What are the relationships between teachers’ access to six chosen features of digital math curriculum resources and (a) school characteristics (e.g., grand band, socioeconomic status), (b) teacher characteristics (e.g., experience), and (c) feature characteristics (e.g., feature choice)?

To answer the research questions, I first reported descriptive statistics as
percentages of teachers who had access to each of the six features, as well as predicted probabilities for access to each feature calculated from the null model of the multilevel logistical regression. These results showed that practice problems and instructional videos were significantly more likely than interactive scenarios for all grade band/socio-economic status combinations except teachers at high income high schools. This showed that traditional teaching methods (in the form of practice problems and instructional videos) still dominate other methods (e.g., interactive scenarios), even when teachers use digital curricula. Next, I used the final model to explore these probabilities within subgroups of the sample. Key results from this analysis showed that high school teachers were significantly less likely than elementary teachers to have access to all features except create/revise content. This sheds light on differences between elementary and high school curricula choices. Based on these findings, it appears that there is an important need for more high-quality digital programs for high school mathematics content, but these should not be developed at the expense of the ability to Create and/or Revise content. Last, the study contributed to the field by finding that significant differences in socioeconomic levels do, in fact, exist regarding digital material use, but only for middle school teachers.

(292 pages)
In 2019, RAND Corporation asked teachers which digital materials they used. This study expanded on this research by exploring the features contained in these programs. The purpose of this study was to investigate the relationships between teachers’ access to features and school (e.g., grand band, socioeconomic status), teacher (e.g., experience), and feature characteristics (e.g., feature choice). I report a significant regression model to predict the likelihood for a teacher to have access to each of the six features within differing contexts based on the characteristics.

To answer the research questions, I first reported descriptive statistics as percentages of teachers who had access to each of the six features, as well as predicted probabilities for access to each feature calculated from the null model of the multilevel logistical regression. These results showed that practice problems and instructional videos were significantly more likely than interactive scenarios for all grade band/socioeconomic status combinations except teachers at high income high schools. This showed that traditional teaching methods (in the form of practice problems and instructional videos) still dominate other methods (e.g., interactive scenarios), even when teachers use digital curricula. Next, I used the final model to explore these probabilities within
subgroups of the sample. Key results from this analysis showed that high school teachers were significantly less likely than elementary teachers to have access to all features except create/revise content. This sheds light on differences between elementary and high school curricula choices. Based on these findings, it appears that there is an important need for more high-quality digital programs for high school mathematics content, but these should not be developed at the expense of the ability to create and/or revise content. Last, the study contributed to the field by finding that significant differences in socioeconomic levels do in fact exist regarding digital material use, but only for middle school teachers.
DEDICATION

To my little Cody Bear –

May you work hard and never give up on chasing your dreams.
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M. Jill Harmon
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CHAPTER I
INTRODUCTION

According to the American Instructional Resources Survey (AIRS) 2019, “The vast majority of teachers – 88% – indicated using digital curriculum resources during classroom instruction” (Tosh et al., 2020, p. 3). This percentage is likely even higher due to the effects of COVID-19. However, during the COVID-19 world-wide pandemic and school shutdowns, parents, teachers, schools, and researchers turned to digital curriculum resources such as Khan Academy, BrainPOP, and Dreambox in an attempt help children continue their education while quarantining in their homes. The effectiveness of these programs is of even greater concern, along with the concerns of teachers and students, about their access to effective programs containing effective features.

Background of the Problem

Research on digital curriculum materials has shown that digital materials have great potential to assist in increasing mathematics achievement (Choppin, 2016; Choppin et al., 2014; Hillmayr et al., 2020). However, research on the effectiveness of digital curriculum has focused more sharply on individual types of tools based on the design features they contain (Choppin, 2016; Choppin et al., 2014; Higgins et al., 2017; Hillmayr et al., 2020). For example, programs that contain the feature of “interactive scenarios” have been shown to greatly improve mathematics achievement, with large effect sizes ($g = 0.65$) (Hillmayr et al., 2020). In addition, digital resources that contain the “adaptive” feature for differentiating mathematics problem sets based on student
performance have shown promising effects on mathematics achievement. Choppin et al. (2014) created a framework of features taken from comprehensive digital curriculum resources. This framework outlines the features surrounding student interactions, curriculum use and adaptation, and assessment systems. Based on Chopin et al.’s (2014) framework, pertinence in the literature, and my interests, I selected six specific features as the focus of this study: instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access. These six features have the potential to greatly impact the effectiveness of digital curriculum and, therefore, positively impact student mathematics achievement (Haelermans & Ghysels, 2016, 2017; Hillmayr et al., 2020; Moyer-Packenham & Westenskow, 2013; Murphy et al., 2014).

The promising effects of digital curriculum containing these features leads one to desire that all teachers have access to them. A recent survey by the RAND Corporation collected data on the specific digital curriculum materials teachers use often. RAND reported percentages of teachers in different subgroups that use each specific curriculum material program. However, research has not explored “more-nuanced definitions and scenarios of digital material use” (Tosh et al., 2020, p. 10).

**Statement of the Problem**

To address this need for “more-nuanced” definitions of mathematics curriculum material programs, research was needed that breaks down the programs by features (Tosh et al., 2020, p. 10). Therefore, this dissertation research study explored the relationship between teachers’ and students’ access to mathematics curriculum material programs and
contextual characteristics. As the research finds more details as to which characteristics and features are optimal to promote mathematics achievement, it is also important to find out what characteristics and features are being used in schools. Therefore, the problem that this study addressed was to determine the relationships between school characteristics (e.g., grade band and socioeconomic status [SES]; Kaufman et al., 2020; Pearman, 2019; Tosh et al., 2020), teacher characteristics (e.g., experience), feature characteristics (e.g., feature choice), and teachers’ access to six specific features within digital curriculum resources for mathematics instruction (e.g., instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access).

This study focused on three premises regarding teachers’ access to features within digital curriculum. The first premise was that there may be a relationship between teachers’ access to features and school characteristics (e.g., grade band and SES). Mathematics curriculum can look very different for different grade bands and for differing SES levels. These differences in curriculum address the different needs of students of different ages as well as help address the need to improve the mathematics achievement gap between social economic statuses of students. The second premise was that there may be a relationship between teachers’ access to features and teacher characteristics (e.g., experience). Teacher experience has been linked to teacher quality and some researchers have argued that higher teacher quality leads to higher achievement (Canales & Maldonado, 2018). The third premise was that there may be a relationship between teachers’ access to features and feature characteristics (e.g., feature choice).
Research has found that when teachers have choice in selecting their curriculum, some teachers tend to select curriculum that has a lower cognitive demand or rigor (Kaufman et al., 2020). But, conversely, having more teacher autonomy has been shown to lead to improved student outcomes (Dierking & Fox, 2013; Ernst et al., 2018). Each of these premises helped to guide the research in this study.

**Purpose of the Study**

The purpose of this study was to understand which school, teacher, and feature characteristics contributed to teachers’ access to features within digital curriculum resources for mathematics instruction. This study began by exploring the features found within digital curriculum resources listed in the AIRS 2019 Survey and reporting percentages of teachers who had access to selected features. In addition, this study examined the relationship between teachers’ access to the features and their school characteristics (e.g., grade band and SES), teacher characteristics (e.g., experience) and feature characteristics (e.g., feature choice).

**Research Questions**

There were two main research questions that guided this investigation.

RQ1: Which of the six features are most commonly present within digital mathematics curriculum resources that teachers report using often? What percentages of teachers have access to each of the chosen features?

RQ2: What are the relationships between teachers’ access to six chosen features
of digital math curriculum resources and (a) school characteristics (e.g., grand band, SES), (b) teacher characteristics (e.g., experience), and (c) feature characteristics (e.g., feature choice)?

**Significance of the Problem**

Great insight can be gained through studying relationships between school, teacher, and feature characteristics and teachers’ access to features within digital mathematics curriculum materials. School characteristics such as grade band and SES (Pearman, 2019; Reardon, 2013; Tosh et al., 2020) are important to consider because teachers within differing school contexts might use programs that provide them with differing features. It would not be surprising to encounter differences in feature access for teachers of differing grade bands because curriculum is often developed specific to each of the different grade bands across K-12 (Schoology, 2020). In addition, teachers in schools with different levels of SES might use programs with different features. In turn, if teachers in low-income schools are less likely to have access to features that have been shown to have a positive relationship with mathematics achievement, this knowledge gives insight into why there may be disparities in student achievement.

Teacher characteristics, such as teacher experience (Çakır & Bichelmeyer, 2016; Canales & Maldonado, 2018; Gerritsen et al., 2017; Inan & Lowther, 2010), are important to study because teachers with different experience levels might have access to different features. Novice teachers might use digital mathematics curriculum more in general because of their experiences growing up with technology, which could then result
in the teachers and their students having access to different features. On the other hand, novice teachers (Attard & Orlando, 2014; Orlando, 2014) might have less access to features simply by the nature of their being new to the field, which may mean that they have not gathered or purchased as much curriculum resources as their more experienced counterparts. Many novice teachers might simply teach mathematics using the materials they are given by their school systems and could possibly choose materials that are easiest to prepare for during their first years of teaching.

Feature characteristics, such as feature choice, are important to study as an aspect of teacher autonomy (Dierking & Fox, 2013; Ernst et al., 2018). It is important to consider which features are in digital mathematics programs that teachers are actually choosing for themselves, and which features are chosen for them by their school or district, because teachers might choose different features than their administrators. For example, it is possible that teachers might be less likely to use programs with the adaptive feature unless they are required to do so by their school.

It is important to consider whether teachers have access to specific learning experience features such as instructional videos, practice problems, and adaptive modalities, because these features have been shown to have a positive impact on learning mathematics, under certain conditions (Haelermans & Ghysels, 2016, 2017; Hillmayr et al., 2020; Moyer-Packenham & Westenskow, 2013; Murphy et al., 2014). Research on specific features is required to determine whether these or other conditions have also been met. However, simply knowing whether teachers are using programs that contain these features allows us to know whether to investigate these conditions further. It is
important to consider teachers’ access to interactive scenarios because research has shown that digital materials containing this feature produces the largest effect size (g=0.65) in its relationship to mathematics achievement (Hillmayr et al., 2020). This would be especially important to consider within differing school, teacher, and feature contexts. For example, if teachers in low-income schools have less access to interactive scenarios, one could argue that greater access could improve mathematics achievement in these schools. It is important to consider whether teachers have access to programs that allow teachers to create or revise content because programs lacking this feature could lead to a significant decline in teacher agency, and as a result, opportunity for training and therefore quality (Borys & Choppin, 2017). Parent data access is important to consider because teachers of differing grade bands, or other teacher contexts, may or may not have access to programs that include parent data access. In addition, further studies could investigate which kinds of data to provide parents that would encourage parental support rather than parental control. Although research on the effectiveness of programs containing these features is incredibly valuable, further research is needed that brings these variables together to explore whether these features and programs are reaching classrooms.

**Summary of Research Study Design**

In this study, I employed a cross-sectional, quantitative, non-experimental survey design using an existing dataset. I obtained data from the RAND Corporation’s American Instructional Resources Survey (AIRS) 2019 for school, teacher, and feature
characteristics as well as data on which specific programs teachers reported using once a week or more. This data on program use was broken down to report which features were contained in each of the programs. I chose six specific features as the focus of this study based on my interest and pertinence in the literature: instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access.

The AIRS 2019 dataset asked teachers which specific digital curriculum programs they used once a week or more. This dataset was the most recent data accessible to researchers outside of RAND Corp. at the time I began the study. Because the survey data are collected annually, once the 2020 data and 2021 data are available, this analysis will prove indispensable as a comparison to those data. Although the 2019 data were gathered prior to the COVID-19 pandemic, this information was gathered nationally through the RAND survey and is still pertinent today because it is likely teachers will return to some of the non-digital options they used prior to the pandemic. As such, these data were the most recent data of teachers’ digital curriculum use with teachers and students in the modality of in-person full time mathematics instruction.

To answer the first research question, I computed simple descriptive statistics, specifically using percentages, to report which of the six features were most common overall and which were most common among different subgroups of the population based on school characteristics (e.g., grade band, SES), teacher characteristics (e.g., experience), and feature characteristics (e.g., feature choice). To answer the second research question, I conducted a 3-level generalized multilevel logistical regression (GLMM), with teachers’ access to each feature as the outcome variable and school,
teacher, and feature characteristics as the multilevel independent variables to predict the probability that each feature type is in a program that is in use and whether these probabilities differ (via interactions) based on the characteristics.

**Definition of Terms**

*Grade band:* groupings of grade levels in schools that would have common goals or needs (e.g., elementary – grades K-5, middle – grades 6-8, and high – grades 9-12).

*Socioeconomic status (SES):* the social status and prestige that is derived from a wide set of economic and social conditions, often measured using family income or qualification for free or reduced-priced lunch (Pearman, 2019; Tosh et al., 2020).

*Teacher experience:* the total number of years a teacher has taught formally in a classroom setting.

*Feature choice:* the extent to which teachers are provided the opportunity to choose the features they have access to by choosing the digital curricular programs that they use.

*Feature of digital curriculum:* any aspect or attribute of digital curriculum resources.
CHAPTER II
LITERATURE REVIEW

This study focused on relationships between school characteristics (e.g., grade band and SES), teacher characteristics (e.g., experience), and feature characteristics (e.g., feature choice) and teachers’ access to features within digital curriculum resources for mathematics instruction.

The review of the literature that follows provides research results to explain three premises of the conceptual framework that guided the study. The discussion begins with a focus on two school characteristics: grade band and SES. The first section reports on prior research on school grade band and its relationship to curricular decisions as well as its role in statistical studies of mathematics achievement. The second section reports on prior research on school socio-economic status and how it is related to curriculum selection and mathematics achievement. The third section includes prior research on one important teacher characteristic, focusing on teacher experience as an aspect of teacher quality and the connection of teacher experience to curriculum resources for mathematics. The fourth section describes prior research on the extent to which teachers are given curriculum choice and autonomy, specifically with regard to digital curriculum resources and the feature choices that teachers are given by school and district leaders. The last section discusses the research on teachers’ access to the features in curriculum resources for mathematics instruction, especially their access to six specific features (e.g., instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access).
Conceptual Framework

The conceptual framework for this study was designed to highlight three important premises about the relationships that may exist between school characteristics (e.g., grade band and SES), teacher characteristics (e.g., experience), feature characteristics (e.g., feature choice) and teachers’ access to features within digital curriculum resources for mathematics instruction (see Figure 1). It is important to study features of technology (which are broad and conceptual), rather than focus on the specific technologies themselves, because specific technologies evolve rapidly, while features are more stable and appear across technologies. This study sought to determine these relationships, not just by reporting descriptive percentages for subgroups of these characteristics, but by considering them collectively in their naturally nested state. The first premise was that school characteristics (e.g., grade band (Schoology, 2020) and SES (Kaufman et al., 2020; Tosh et al., 2020) may be related to teachers’ access to features, because it is expected that teachers in differing school contexts are likely to choose or be assigned programs containing differing features. Elementary teachers and teachers at Low SES schools have students with very different needs than those at High SES schools, and therefore different curriculum resources for mathematics instruction might fill those needs. The second premise was that teacher characteristics (e.g., experience) may be related to teachers’ access to program features because novice teachers might make different choices than experienced teachers about curriculum resources for mathematics instruction, which gives them access to different program features. The third premise was that feature characteristics (e.g., feature choice) may be related to teachers’ access to
program features because features within programs that are required by a school or school district might be different from features in programs that teachers choose for themselves.

**Figure 1**

*Conceptual Framework*

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The relationship between curriculum and grade band is very well established. This section discusses the use of grade band in the field of mathematics education and prior research concerning grade band as a school characteristic, specifically its relationship to curricular choices. It is common practice in the field of mathematics education to

---
delineate curriculum and research by grade band or grade level. When the National Council of Teachers of Mathematics released the Principles and Standards for School Mathematics (2000), their standards were separated into four main grade bands (e.g., Pre-K-2, Grades 3-5, Grades 6-8, and Grades 9-12). Similarly, when the Common Core State Standards for Mathematics were released by the National Governors Association (2010), these mathematics standards were also released by grade band. Like standards documents, teacher professional development and pre-service teacher training programs in mathematics are often divided by grade band. In addition, curriculum is often published in groupings by grade band. This demonstrates the importance and standard practice of using grade band as a way of grouping grade levels and content in mathematics. This is important because many curricular decisions depend on the grade band of the students. Thus, teachers of different grade bands might have access to different curricular programs, which in turn have different features available within them.

Teachers of different grade levels make different curricular decisions in mathematics. One of the topics that is influenced by grade band is parent involvement. For example, Schoology (2020) teachers of all grade bands reported a similar lack of parent involvement (between 25 and 34% of teachers), however, improving parent involvement was selected as a top priority more often for lower grade bands than for higher grade bands. Parent involvement may play a role in the digital materials teachers access, because teachers of lower grade bands might be more likely to use programs that have the option for parents to be able to access the data. Similarly, blended/hybrid learning appears to be more common among higher grade bands (e.g., ranked as 4 by Pre-
K teachers, 3 by K-8 teachers, and 2 by Grades 9-12 teachers). This preference for blended/hybrid learning might mean that teachers of higher grade bands are more likely to use mathematics curriculum programs that contain instructional videos (Schoology, 2020). It was important to examine grade band as a variable in the present study because students in different grade bands have different curricular needs.

Many survey reports on curriculum use delineate results by grade band (Bay-Williams, 2016; Perry et al., 2017; Schoology, 2020). For example, Perry et al. restricted their survey to only grades K-8, but when reporting which curriculum schools use, they delineated by elementary (Grades K-6) and middle (Grades 7-8) grade bands. Many statistical studies in the field of mathematics education include grade band as a moderator variable (Fang et al., 2019; Hillmayr et al., 2020). For example, Hillmayr et al. restricted their sample to only include secondary grades (5-13) in a meta-analysis of 92 studies on the relationship between digital tools and mathematics and science learning. But they also tested grade band (Grades 5-7, Grades 8-10, and Grades 11-13) as a potential moderator of the relationship between using digital tools and learning. They found that grade band was not a significant moderator. This is important because, in this study, I did not assume that grade band would have an effect on feature access but sought to explore this potential.

Other statistical studies restrict their samples and/or use grade band as a covariate. For example, Pane et al. (2014) restricted their sample to only students taking the Algebra 1 course, and even split their study into “two parallel experiments, one in middle schools and one in high schools” (p. 127). However, similar to others, (Haelermans & Ghysels,
they also included grade level as a covariate in order to consider its interaction effects. Pane et al. found significance for high school after year 2, but not for middle school. This is important because using grade band as a covariate controls for differences that might occur because of the grades in each school.

**School Characteristic: Socioeconomic Status**

This section covers the relationship between socio-economic status (SES) and mathematics achievement and discusses how this impacts curricular choices. Research shows a statistically significant relationship between family income and achievement (Pearman, 2019; Reardon, 2013), and researchers seek to discover other confounding variables that may be contributing to this association (Chmielewski & Reardon, 2016). For example, Chmielewski and Reardon (2016) conducted an international study and found that more student tracking and less standardization are statistically associated with larger achievement gaps between school achievement and family income.

Although some researchers disagree about whether the percent of students in a school who receive Free or Reduced-Priced Lunch (FRPL) is an accurate indicator of SES (Domina et al., 2018), they often concede that it is at least an indicator of educational disadvantage. Regardless, FRPL is commonly used as an indicator for SES especially as a school-level indicator of the percent of students in a school qualifying for FRPL (Huang et al., 2016; Murphy et al., 2014; Pane et al., 2014; Pearman, 2019; Tosh et al., 2020). Whether SES is indicated by family income or percent of FRPL, it is commonly used as a main variable of interest in statistical studies on mathematics
achievement (Huang et al., 2016; Lombardi & Dearing, 2020; Qiu & Wu, 2019). For example, Lombardi and Dearing (2020) found that maternal support was a mediator of the relationship between family income and mathematics achievement. In a curricular study, Huang et al. (2016) found that an adaptive program called Assessment and Learning in Knowledge Spaces (ALEKS) statistically reduced the achievement gap for their sample of sixth-graders in an after-school program. More specifically, the three-way interaction between SES (percent of FRPL), gender, and race was significant for the control group, but not significant for the treatment group that used ALEKS, thus leveling the playing field. This is significant, especially in light of Chmielewski and Reardon’s (2016) results about student tracking having an association with an increased achievement gap. Adaptive features track students within the ALEKS program, allowing them to have access to mathematics at their ability level, while still allowing them to remain physically amongst their age-level peers. This research finding was important to this study because I used percent of FRPL as a school-level indicator of SES in a statistical model to determine whether teachers in schools with different SES levels are more or less likely to use programs that have adaptive features.

Because it is generally accepted that SES has an association with mathematics achievement, many studies simply control for SES in statistical models (Baker, 2015; Canales & Maldonado, 2018; Darling-Hammond, 2000; Haelermans & Ghysels, 2016; Pane et al., 2014), while others report these as descriptive statistics (Attard, 2013; Craig et al., 2013; Murphy et al., 2014; Richey et al., 2020). For example, Darling-Hammond (2000) used student poverty as a control variable to show that teacher quality
(specifically greater teacher preparation and certification) still has a strong relationship to student achievement. In regard to curricular decisions, Murphy et al. (2014) simply reported descriptive statistics of SES (percent of FRPL) for their sample on the significant impact of Khan Academy on mathematics achievement as a supplemental resource.

With the achievement gap as an ever-present concern, it is likely that teachers in low-income schools would make different curricular decisions than those in higher income schools. Tosh et al. (2020) of RAND Corporation found that teachers of low-income students, especially of English Language Learners, are more likely to use digital materials in general. In addition, Tosh et al. (2020) reported that teachers of low-income students are more likely to report using a digital material as one of their two to three main materials. This study investigated this trend to see if teachers working with different groups of students were more likely to use materials with specific features. For example, teachers with more low-income students may be more likely to use programs that are adaptive, such that the digital curriculum program gives every student different mathematics content based on their skill level.

Teacher Characteristic: Experience

Another factor that could impact teachers’ access to features of digital curriculum resources is teacher experience. This section will discuss prior research on teacher experience (in terms of years of experience) and its statistical relationship to mathematics achievement, as well as its relationship to digital curriculum choice. It is important to
examine teacher experience as a teacher characteristic variable because teacher experience could be an indicator of teachers’ access to features of digital curriculum resources.

Teacher experience is often considered a component of teacher quality (Gerritsen et al., 2017; Qiu & Wu, 2019). Many researchers use teacher experience as a significant covariate when making predictions about improving mathematics achievement (Çakır & Bichelmeyer, 2016; Canales & Maldonado, 2018; Gerritsen et al., 2017; Inan & Lowther, 2010). For example, Canales and Maldonado (2018) found that teacher experience had a significant cubic relationship with mathematics achievement, but not reading achievement. As another example, Gerritsen et al. found that mathematics achievement statistically significantly improved with greater teacher experience. According to Flores (2007), even though teacher quality and teacher experience is not the cause of the achievement gap, that does not mean it may not play a role in assisting to close the gap.

In studies on the use of digital curriculum resources, some researchers have focused on restricting their participant sample based on teachers’ experience, and examined teacher groups such as preservice teachers, novice teachers, and veteran teachers (Attard & Orlando, 2014; Orlando, 2014). For example, Attard and Orlando found that early career teachers successfully implemented Interactive Whiteboards for teaching mathematics but implementing iPads with their students proved to be much more challenging. This is important because, in this study, I compared early career teachers with veteran teachers.

Such comparisons between teachers with different levels of experience are often
made within large survey studies on curriculum use (Schoology, 2020; Tosh et al., 2020). For example, Schoology found that 69% of teachers use Twitter for professional growth, and this was especially true of teachers with 11-20 years of teaching experience. As another example, using the AIRS 2019 dataset, Tosh et al. found that there were no significant associations between teacher experience and individual digital program use. This was important to this study because I used the same AIRS 2019 dataset to further investigate this relationship, but by categorizing the programs by feature. This allowed me to consider the relationship between teacher experience and features contained within digital programs.

**Feature Characteristic: Feature Choice**

The characteristic of “feature choice” is the extent to which teachers are required to use the digital curriculum programs that contain the features of interest. Teachers’ ability to choose the digital curriculum programs they use, rather than to have the programs chosen for them by their school administrators and districts, is often referred to as “teacher autonomy” in literature. This section will discuss prior research on the value of teacher autonomy and the extent that teachers have choices in their schools, especially with regard to their choice of curriculum programs. This was an important indicator in this study because teachers might choose digital curriculum programs with different features than their school or district would choose.

Some researchers have expressed concern that passing certain educational policies, such as No Child Left Behind, the subsequent Every Student Succeeds Act, and
the Curriculum and Assessment Policy Statement in South Africa, has increased states’ and countries’ pressure to perform. This has caused the implementation of stricter guidelines and expectations for schools and teachers, which has also compromised school and teacher autonomy (Ernst et al., 2018; Ramatlapana & Makonye, 2012; Strong & Yoshida, 2014).

Many researchers assert that there is great value in providing teachers with autonomy, benefiting both teachers and students. Teachers with more autonomy have been found to have increased job satisfaction, decreased stress, and more professionalism, empowerment, and self-confidence (Dierking & Fox, 2013; Ernst et al., 2018; Pearson & Moomaw, 2005; Skaalvik & Skaalvik, 2014; Wright, 2018). Additionally, students have been found to have greater motivation and sense of school belonging when their teachers have greater autonomy (Froiland et al., 2016).

Researchers disagree on the relationship between teacher autonomy and teacher retention. Some report that increased teacher autonomy has a relationship with increased teacher retention. (Byrne, 1999; Ingersoll et al., 2016; Wright, 2018). However, others report that teacher autonomy is not a contributing factor for a teacher leaving a school (Boyd et al., 2011; Redding et al., 2019).

Last, some have argued that teachers who make their own choices about curriculum, or “DIY teachers,” tend to choose resources that reduce cognitive demand or rigor, which is not beneficial for students (Kaufman et al., 2020; Stein et al., 1996; Stein & Kaufman, 2010). However, this does not mean that teachers should not have autonomy; this simply means that teachers need training and support in the use of higher
expectations. In fact, in schools where students perform better in mathematics than their expected demographics, school leaders reported that teachers had greater autonomy (Bullock, 2017). This research demonstrates the importance of teacher autonomy to the variable of “feature choice” used in this study. Feature choice may be important in the selection of instructional materials in relationship with teachers’ access to features within digital curriculum resources for mathematics instruction.

**Access to Features**

The focus of this study was to understand how school, teacher, and feature characteristics contributed to teachers’ access to features within digital programs that they reported using often, specifically once a week or more. This section discusses the literature on the features within the digital programs. It is important to make a distinction between feature choice and teacher access to features. Feature choice is a variable defined as a feature that a teacher has the choice, or autonomy, to choose to use. Feature choice indicates whether or not a teacher is required to use a digital program containing the feature, or if the teacher has the choice to use the digital program. In contrast, access to features indicates whether or not a teacher has access to a feature because that feature is present in at least one or more of the digital programs that the teacher uses on a regular basis for mathematics instruction. The following sections discuss the literature on six different features of digital programs chosen to be studied in this proposed research (e.g., instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access).
**Instructional Videos**

The first feature that might be present in a digital curriculum resource program is instructional videos. Instructional videos are recorded presentations focused on a particular mathematics topic with the intention that students watching the video will learn. It is a feature that is prevalent within many comprehensive curriculum materials (such as LearnZillion and Khan Academy) but can also be searched for and found in a variety of searchable repositories, such as YouTube and Teachers Pay Teachers.

According to Choppin et al. (2014), among comprehensive digital curriculum, the use of videos is the most common feature intended for students’ learning experiences. While still uncommon among preservice teachers (Gay et al., 2020), in-service teachers and students are using instructional videos more and more, and students report using them almost half of the time (Project Tomorrow, 2015). Although no research findings have statistically significant differences in mathematics achievement with a comparison group, results are generally positive (de Araujo et al., 2017; Hsin & Cigas, 2013; Kelly & Rutherford, 2017; Murphy et al., 2014; Zengin, 2017). For example, Kelly and Rutherford found that minutes spent in Khan Academy were statistically significantly related to topics mastered in the program, but not significantly related to mathematics achievement. In addition, Zengin found statistical improvement from pretest to posttest when Khan Academy was used in a flipped classroom model. Murphy et al. found that for some sites and some grade levels there was a statistically significant relationship between minutes spent in Khan Academy and higher than predicted mathematics achievement scores, as well as between problem sets completed and mathematics
achievement. It is important to note that, in all of these studies, instructional videos were used in addition to other classroom activities, as a supplementary activity, and teachers were rarely using videos to introduce new mathematics topics (de Araujo et al., 2017; Hsin & Cigas, 2013; Kelly & Rutherford, 2017; Murphy et al., 2014; Zengin, 2017). The flipped classroom approach is the only model to advocate for videos introducing new concepts, but this model is still rarely used in schools (de Araujo et al., 2017; Project Tomorrow, 2015; Zengin, 2017). Even when videos are successfully implemented as part of an online course, they are still accompanied by other learning experiences (Hsin & Cigas, 2013). This is important because this dissertation study did not specifically consider how the videos were used in the classroom, but this would be an important consideration for future studies.

Interactive Scenarios

The second feature that might be present in a digital curriculum resource program is interactive scenarios. The full title of this feature, as given by Choppin et al. (2014), is “Interactive scenarios in which students manipulate representations to solve problems” (p. 18). Described in this way, one might consider virtual manipulatives to fall in this category (Moyer-Packenham & Bolyard, 2016). Research over several decades has gleaning large amounts of evidence that interactive scenarios lead to improved mathematics achievement more than other treatments (Hillmayr et al., 2020; Moyer-Packenham & Westenskow, 2013). These are similar to what Hillmayr et al. (2020) calls “dynamic mathematical tools,” that specifically allow the user to manipulate mathematical expressions (Hillmayr et al., 2020, p. 5). Research has yet to investigate the
extent to which teachers have access to this type of digital tool in their teaching, a finding which this study will report. This is important because knowing which subgroups of schools or teachers may or may not have access to this feature could shed light on this feature. For example, if teachers in low-income schools have less access to interactive scenarios, one could argue that greater access could improve mathematics achievement in these schools.

**Practice Problems**

The third feature that might be present in a digital curriculum resource program is practice problems. Practice problems are a feature within many digital curriculum resources. These resources often provide students with a typical textbook mathematics problem which the student then solves, types in the answer, and then the student is provided with feedback on the correctness of their answer. Research has shown that a program containing only practice sets alone is not enough to improve learning (Hattie & Timperley, 2007; Hillmayr et al., 2020; Wisniewski et al., 2020). Additional features are required such as explanatory feedback (Haelermans & Ghysels, 2017; Hattie & Timperley, 2007; Hillmayr et al., 2020; Van der Kleij et al., 2015; Wisniewski et al., 2020) and/or adaptive features (Haelermans & Ghysels, 2017; Hagerty & Smith, 2005; Pane et al., 2014) in order to produce improved achievement. For example, in a meta-analysis conducted by Van der Kleij et al., which only included studies that used a comparison group, researchers reported larger effect sizes for explanatory feedback (providing an explanation) over correctness feedback or providing the correct answer, and increased effect sizes for mathematics achievement.
Though not shown as significantly better than comparison groups, the previous section of this literature review reported on successful learning when practice sets also include videos, specifically with Khan Academy. In fact, many teachers reported simply assigning their students to complete practice sets in Khan Academy and only watch videos as needed (Murphy et al., 2014). Similarly, though not found to be significantly better than control groups, the next section of this literature review will report on how including adaptive features with practice sets can support learning. Last, Hillmayr et al. (2020) conducted a meta-analysis of digital curriculum that compared five types of digital tools, and they found that interactive and enhanced explanatory feedback had higher effect sizes than practice sets with lower levels of feedback. This is important because, although this dissertation study did not consider whether each program with practice problems also had these additional features, this study did consider whether the teacher had access to most of these other features. Because this dissertation study did not consider explanatory feedback, this would be an important consideration for future studies.

**Adaptive**

The fourth feature that might be present in a digital curriculum resource program is adaptability. For the purpose of this study, digital curriculum resources that are “adaptive” “assign new content or activities to students based on their performance within an online assessment built into the program” (Choppin et al., 2014, p. 18). The term “adaptive” is used very differently by Hillmayr et al. (2020). For example, they describe “intelligent tutoring systems” as adaptive because they scaffolded solution
strategies within a single problem (Hillmayr et al., 2020). However, this is a completely different feature entirely that was not a consideration for the current study.

Research has shown that when programs adapt the assignment of problem sets, this significantly improves students’ mathematics achievement (Haelermans & Ghysels, 2017; Hagerty & Smith, 2005; Pane et al., 2014). However, the majority of research, including a meta-analysis of research on ALEKS, reported no difference between these programs and other treatments (Fang et al., 2019; Lovett et al., 2008). Some authors argue that there are other various reasons to use these programs, while others give reasons against them (Lovett et al., 2008; Xu et al., 2009). This is important because teachers in differing contexts might have access to programs with the adaptive feature while others do not.

**Create/Revise Content**

The fifth feature that might be present in a digital curriculum resource program is the capability to “create and/or revise content.” Programs that include this feature allow teachers to manually change elements that are part of students’ learning experiences. For example, LearnZillion allows teachers to download their presentations for editing in Microsoft PowerPoint (Choppin et al., 2014). The create/revise content feature has not been studied as a feature of digital curriculum resources, and therefore, little is known about whether digital curriculum programs containing the capability to create or revise content might lead to greater or lower mathematics achievement. However, this once again goes back to teacher autonomy. Some argue that giving teachers autonomy in general, including over content, leads to greater mathematics achievement (Bullock,
2017). In addition, the design of some digital curriculum resources could lead to a significant decline in teacher agency, and as a result a decline in the opportunity for training and therefore quality (Borys & Choppin, 2017). This is important because, whether by choice or by school or district mandate, some teachers might be less likely to have access to digital curriculum resources that allow them to create or revise content.

**Parent Data Access**

The sixth feature that might be present in digital curriculum resource programs is parent data access. Parent Data Access is a feature that exists in many digital curriculum resources that allows parents to have the ability to log in and view data concerning their child’s use and scores. Parental involvement has consistently been shown to improve younger children’s mathematics achievement, whether by direct assistance with mathematics or simply increased access to their grade portal (Baker, 2015; Dries, 2014; Lombardi & Dearing, 2020). However, as students age, this may no longer be the case. One study found that when parents had access to their child’s practice behavior on a digital tool, seventh-graders had significantly greater success, whereas eighth-graders had significantly lower success (Haelermans & Ghysels, 2016). Even though, in this study, both of these teachers were considered middle school, it will still be valuable to examine which grade bands have programs that allow parents to access the data. This is significant because it leads to questions about the relationship between parent involvement, age of the child, and the specific nature of the parent involvement (direct assistance vs. behavior monitoring). Silinskas and Kikas (2019) found that low self-concept in mathematics predicted increased parental control (vs. parental support), which in turn predicted low
mathematics performance, low task persistence, and continued low mathematics self-concept over time. This was important to this study because teachers of differing grade bands, or other teacher contexts, may or may not have access to programs that include parent data access. In addition, further studies could investigate which kinds of data to provide parents that would encourage parental support rather than parental control.

**Summary of the Literature**

The previous sections presented a review of the literature on teachers’ access to features within digital mathematics curriculum resources and a conceptual framework. The research on digital curriculum resources shows that the effectiveness of materials relies heavily on the features they contain. Although research has been conducted to determine which specific programs teachers are using, no research has been conducted to examine these programs by feature to determine what features teachers have access to and the relationship between this access and school characteristics (e.g., grade band and SES), teacher characteristics (e.g., experience), and feature characteristics (e.g., feature choice). Therefore, this study examined the relationships between these characteristics and teachers access to six specific features (e.g., instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access) in digital curriculum resources.
CHAPTER III

METHODS

The purpose of this study was to understand which school, teacher, and feature characteristics contributed to teachers’ access to features within digital curriculum resources for mathematics instruction. In this study, I explored the features found within digital curriculum resources listed in the AIRS 2019 and reported percentages of teachers who had access to six selected features. I also examined the relationship between teachers’ access to the features and their school characteristics (e.g., grade band and SES), teacher characteristics (e.g., experience) and feature characteristics (e.g., feature choice).

Context of the Study

This study was set in the context of an international public health crisis caused by the emergence of a severe acute respiratory syndrome coronavirus 2 (SARS-CoV2) that resulted in a global pandemic. Because of national public health guidelines and university institutional guidelines on the conduct of research with human participants, the use of existing data sets to conduct dissertations during this time period was strongly encouraged. To align with these guidelines, I chose to use an existing dataset gathered by the RAND Corporation in 2019. This existing dataset was gathered using a national survey to examine teachers’ curriculum use.
Research Questions

Two research questions guided this investigation.

RQ1: Which of the six features are most commonly present within digital mathematics curriculum resources that teachers report using often? What percentages of teachers have access to each of the chosen features?

RQ2: What are the relationships between teachers’ access to six chosen features of digital math curriculum resources and (a) school characteristics (e.g., grand band, SES), (b) teacher characteristics (e.g., experience), and (c) feature characteristics (e.g., feature choice)?

Research Design

The research design for this study was a cross-sectional, quantitative, non-experimental survey design utilizing existing data (Creswell, 2014; Johnston, 2014). The design was cross-sectional because data were collected at a single point in time (Creswell, 2014), specifically Spring 2019. The design was quantitative because responses to a survey served as a sample to create a model with the intent of generalizing to a population (Creswell, 2014). The design was non-experimental in the sense that no experiment was conducted (Creswell, 2014). This design allowed me to generalize the characteristics of digital materials that teachers reported and their relationship to student, teacher, and feature characteristics. To address the research questions, I used a feature framework (Choppin, 2016; Choppin et al., 2014) to create a new feature “access” variable from the AIRS 2019 data, reported descriptive statistics on this variable, and
then reported results on a multilevel logistic regression model.

There were advantages and disadvantages to using this type of design. One advantage of a secondary analysis on existing data was that it gave me the opportunity to use a larger, high-quality dataset than might otherwise be obtained by a typical doctoral student with limited resources, which allowed for the potential of higher validity and generalizability (Johnston, 2014). One disadvantage to using an existing data set was that the original purpose of collecting the data might have differed from the purpose of my secondary analysis (Johnston, 2014). This limitation was considered in the design. Although the purpose of this study was different from the original study conducted by the RAND Corporation, I was confident that the data were sufficient to answer the research questions.

Procedures

Once RAND Corporation collects data using the AIRS every year in the spring, their researchers analyze and report on the data for a year and a half before releasing the data in two forms: deidentified and restricted. The deidentified data is released to the public with all private information removed. The restricted data are shared with select individuals for a fee once the individuals have prior IRB approval. Both forms of data require a login to access the AEP database, from which files can be downloaded and used to conduct secondary analyses.

Once I obtained IRB approval, I applied for the restricted version of the dataset and paid the $2,000 fee to acquire it. The process of applying for the restricted data
required me to write a short proposal to RAND Corporation (included in Appendix B), along with proof of my IRB approval. Once RAND approved my application, they emailed me a link to download a customized version of the dataset in the form of a .csv file. I was then able to use the data for analysis by filtering the data for only teachers of mathematics and then combining it with data about features within each of the digital curriculum resources for mathematics instruction.

Data Source

Description of the AIRS 2019

The source of data for this study was the AIRS 2019 administered by RAND Corporation. RAND Corporation is an organization with experts in research who are focused on conducting high quality research on public policy (RAND Corporation, n.d.-b). RAND has strict standards for their research studies which contributes to their reputation of high quality and objectivity in the development of their instruments and methods. Through partnership and sponsorship, RAND Corporation designed the American Educator Panels (AEP) to survey educators across the United States. This created datasets which can then be weighted to be a nationally representative sample (RAND Corporation, n.d.-a). Although the AEP currently consists of two panels, this study focused on only one: The American Teacher Panel (ATP). With more than 25,000 participating teachers in 12 states, the ATP was designed to facilitate national analyses, including national analyses of particular subgroups, such as elementary, subject, and urbanicity.
AIRS 2019 was the first in its series with the ATP and has been conducted every year since. On May 14, 2019, RAND Corporation sent an email to 10,772 teachers inviting them to participate in AIRS 2019, with the goal of obtaining 6,300 completed surveys. They yielded 5,969 responses from teachers. The main purpose of AIRS 2019 was to investigate specific instructional materials used by teachers and students. Although the AIRS 2019 included science, ELA, and mathematics data, this dissertation study focused solely on the mathematics data, by only examining survey responses from teachers of mathematics. In addition, although the AIRS 2019 focused broadly on instructional materials in general and factors related to it, this dissertation study focused specifically on the use of digital curriculum resources for mathematics instruction and its related factors. Although AIRS 2019 data was gathered prior to COVID-19 pandemic, the information is still pertinent because we could compare future data with the results from this study to determine changes over time (e.g., year to year) and during and after the COVID-19 pandemic (e.g., virtual learning, hybrid learning, and in-person learning).

This study centered around Question 604 from the AIRS 2019. As shown in Figure 2, this question simply presented teachers with a list of 29 programs (e.g., Dreambox or Reflex) and two checkboxes for each program. Teachers were asked to mark all programs that their students “use once a week or more on their own during classroom instructional time” for the first checkbox. For the second check box, they were asked to mark whether they, themselves, used each program “once a week or more during whole-class instructional time or to plan instruction” (RAND American Educator Panels, 2019, pp. 29–31).
**Figure 2**

_preview of Question 604 of AIRS 2019_

Please indicate which digital materials your students and/or you use regularly (once a week or more) for mathematics instruction this school year (2018-19). If you do not use a resource, skip that row and move on to the next one.

**SELECT ALL THAT APPLY IN EACH ROW**

<table>
<thead>
<tr>
<th></th>
<th>My students use this once or week or more on their own during classroom instructional time</th>
<th>I use this once a week or more during whole-class instructional time or to plan my instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>703 ALEKS</td>
<td>1 □</td>
<td>2 □</td>
</tr>
<tr>
<td>704 Amplify</td>
<td>1 □</td>
<td>2 □</td>
</tr>
<tr>
<td>749 YouTube</td>
<td>1 □</td>
<td>2 □</td>
</tr>
<tr>
<td>791 Other (please describe):</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>799 N/A – No digital materials are used regularly</td>
<td>1 □</td>
<td>2 □</td>
</tr>
</tbody>
</table>

This question was asked because the main purpose of AIRS was to investigate instructional materials. However, the main purpose of this study is to investigate the features within these programs. Therefore, each program was analyzed for the presence of the six features of interest, and a new “access” to feature dichotomous variable was created to indicate whether the teacher had access to each feature, meaning the feature was present in at least one program the teacher reported using often. Thus, “access” to feature became a variable such that a 0 or “No” meant that neither they or their students use any programs from the list that contain that feature, and a 1 or “Yes” meant that the teacher used at least one program often (either for them or their students) that contained that feature.
**Participants: Inclusion/Exclusion Criterion**

Once the AIRS 2019 dataset was filtered to just mathematics teachers, the data included 2,027 teachers. As seen in Figure 2, at the bottom of the list of programs on question 604 there was an “Other (please describe) _____” option and a “N/A – No digital materials are used regularly” option. The 223 teachers who marked “N/A - No digital materials are used regularly” were assigned “No” for the access variable for all six features because they did not use any programs that contained any of the six chosen features. For the 80 teachers who only marked “Other (please describe) _____,” it was not feasible to analyze these programs for which features they contained. As such, these teachers were excluded from the analysis. Last, there were 20 teachers who broke protocol when they did not mark that they used any programs, but they also did not mark “N/A – No digital materials are used regularly.” These individuals likely did not complete the survey and were also excluded from analysis. This brought the number of teachers in the potential sample to \( n = 1927 \).

Last, teacher experience and SES had missing data. For teacher experience there were 37 teachers missing this data, which I presume just meant that they skipped the question. For SES, there were 26 teachers with missing data. This left me with 1,864 teachers in the final sample. Figure 3 shows this progression of exclusion visually.

Of the 1,864 mathematics teachers participating in the study, 1,014 were elementary teachers, 458 were middle school teachers and 392 were high school teachers. These teachers could reside and teach in any of the 50 states in the U.S., with larger numbers of teachers residing in one of 12 states for state-representative sampling:
California, Delaware, Florida, Louisiana, Massachusetts, Mississippi, Nebraska, New Mexico, New York, Rhode Island, and Wisconsin (RAND Corporation, n.d.-c). An additional 466 teachers responded who reside in a state other than these twelve. For confidentiality’s sake, RAND Corporation did not disclose the specific states where these teachers reside; they were simply categorized as “Other.” The teachers in the dataset had experience teaching in grades Kindergarten to 12th grade. The average number of years of
teaching experience for the teachers in the data set was 14.45, ranging from 1 to 47 years of teaching.

Data Analysis

Data analysis occurred in three main phases. During the first phase, prior to obtaining the AIRS 2019 dataset, I created a data file containing the list of digital curriculum materials found on question 604 of the AIRS 2019 and categorized the materials for whether or not they contained each of the six features of interest for this study (e.g., instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access). During the second phase of the analysis, I obtained the AIRS dataset and prepared the data for use in the analyses. During the third phase, I conducted statistical analyses for the two research questions. The sections below present an overview of the research questions, data sources, and data analyses and provide details on the procedures that were used in each of these three main phases.

Overview of Research Questions, Data Sources, and Data Analysis

Table 1 shows the connection between the research questions, data sources, and data analysis. To answer the first research question, I computed basic descriptive statistics, mainly percentages, concerning teachers’ access to features within digital curriculum resources for mathematics instruction. Next, I began the process of modeling via generalized mixed effects regression (GLMM), specifically the logistic generalization (Binomial distribution and logit link). While fixed effects account for the role of each
predictor on the dependent variable (access = yes/no), the lack of independence between the features is captured by random effects (i.e., random intercepts). The results from the null model (no predictors included, only nesting of repeated measures) were reported to further answer the first research question. To answer the second research question regarding school, teacher, and feature characteristics, these independent variables were added to the GLMM analysis.

Table 1

Overview of Research Questions, Data Sources, and Data Analysis

<table>
<thead>
<tr>
<th>Research question</th>
<th>Data sources</th>
<th>Data analysis</th>
</tr>
</thead>
</table>
| RQ1: Which of the six features are most commonly present within digital mathematics curriculum resources that teachers report using often? What percentages of teachers have access to each of the chosen features? | AIRS 2019 | Basic descriptive statistics  
Percentages of teachers  
Null Model of Multilevel Logistic Regression |
| RQ2: What are the relationships between teachers’ access to six chosen features of digital math curriculum resources and (a) school characteristics (e.g., grand band, SES), (b) teacher characteristics (e.g., experience), and (c) feature characteristics (e.g., feature choice)? | AIRS 2019 with new feature variables | Multilevel Logistic Regression  
DV = Access  
(0 = No, 1 = Yes)  
IV1 = Grade Band  
IV2 = SES  
IV3 = Experience  
IV4 = Feature Choice |

Categorizing the Programs by Feature

Using the already published AIRS 2019, I created a separate data file containing the list of digital materials found on question 604 and categorized them for whether or not they contained each of the six features chosen for this study. You will recall that Question 604 (see Figure 2) presented teachers with a list of programs and asked them to mark which programs they used often. Next, I put the list of programs into a separate
spreadsheet in a single column with six additional columns for each of the six features (e.g., instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, parent data access). Each program was assigned a 1 or “Yes” if the program contained the feature and a 0 or “No” if the program did not. I accessed and reviewed each program thoroughly to determine which response to select. This sometimes involved contacting the programs’ creators to gain demo access to the program (such as with LearnZillion). Another strategy was to find videos online of individuals recording themselves using the programs (such as with Prodigy).

Preparing the Data for Analysis

Once I downloaded and imported the dataset into R, I filtered it to include only teachers of mathematics. Additionally, I filtered the dataset to only include variables containing information related to school, teacher, and feature characteristics, and to question 604, which asked about the digital curriculum each teacher used often (see Figure 2). I collapsed the two parts of question 604 that had separate checkboxes to clarify how the program was used to simply reflect all programs that were used often. Next, I combined this filtered data in R (see Appendix D) with my other data file that categorized each program by the six features of interest. This allowed for the creation of my dependent variable: “access” to feature, which gave each teacher six rows, one for each feature. These were assigned a 1: “Yes” to indicate that the teacher uses at least one program often (either for them or their students) that contains the feature or a 0: “No” if they do not.

Each variable was formed and formatted as described in detail in the following
section. These variables were analyzed descriptively to answer the first research question. To answer the second research question, the variables were then used in a multilevel logistical model to predict the likelihood of teachers in differing contexts having access to each of the features of interest.

**Variables**

The analysis required three types of variables: hierarchical structure indicators (i.e., indicator variables), various independent variables, and the dependent variable. Indicator variables (i.e., school, teacher, and feature) were used to identify units that make up the structural levels in the multilevel model. The dependent variable was feature “access” (binary: yes vs. no). The independent variables were characteristics specific to each school, teacher, or feature.

**Hierarchical Structure: Indicator Variables**

The inherent hierarchical structure of the data would have used three indicator variables, one for each level of the sample: school, teacher, and feature. However, in the process of obtaining data access I learned that it was rare to have more than one teacher in the same school respond to the survey. Thus, the variables I had planned as school-level variables had to be analyzed on the teacher-level to produce a two-level logistical regression model.

Nested within each school, there was a sample of meso-units (teachers) forming Level 2. The teacher indicator variable was also a simple ID number, one for each teacher who completed the AIRS 2019. Nested within each teacher was the set of “features” that
functioned as the micro-units that made up Level 1. The “feature” indicator variable was a factor variable containing the six different features (e.g., instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access). Within each of these levels, there were characteristics that were investigated as independent variables predictive of the dependent variable (“access” to feature).

**Independent Variables: School, Teacher, and Feature Characteristics**

Four independent variables were chosen from the dataset to explore relationship and interaction effects on access to digital curriculum features. These included two variables that would have been at the school level but now must be considered at the teacher level (grade band, SES), one variable at the teacher level (experience), and one variable at the program level, which was collapsed to be on the feature level (choice).

**School characteristic: Grade band.** The AIRS 2019 was set up into sections based on grade band and subject taught. Although none of the questions used in this study were grade band specific, the survey had specific questions routed to elementary teachers that were different than those routed to middle and high school teachers. They determined that, because fewer teachers would be considered “middle school” (i.e., 6th – 8th grade), a teacher who indicated teaching any of these three grades would automatically be routed to the middle school path. This means that some teachers who were categorized as “middle school” might actually teach at an elementary school. I used this same categorization for this analysis to create an ordinal teacher level variable with 3 categories (elementary, middle, and high school). Teachers were assigned as elementary
school if they taught any grades K-5, but not 6th – 8th. Teachers were assigned as middle 
school if they taught any grade 6th -8th, even if they also taught a grade outside this range. 
Last, teachers were assigned as high school if they taught grades 9th – 12th but not any 6th 
– 8th.

**School characteristic: Socioeconomic status.** A variable was used as an 
indicator of SES following the same procedure as Tosh et al. (2020). Although the 
information for this variable was not gained directly from the AIRS 2019, RAND 
included this information in their analysis of digital materials using data from the 2016 -
2017 National Center of Education Statistics (n.d.). Common Core of Data (CCD). Even 
though they used a numerical variable containing the percentage of students in a school 
receiving Free or Reduced-Price Lunch (FRPL), for confidentiality reasons, RAND 
Corporation could only provide this information as a four-level categorical variable (i.e., 
1. 00.0% - 25.0%, 2. 25.1% - 50.0%, 3. 50.1% - 75.0%, 4. 75.1% -100.0%). This metric 
was selected for SES because a school’s percentage of students who qualify for FRPL is 
commonly used as an indicator of school poverty or socio-economic status (Domina et 
al., 2018; Pearman, 2019; Reardon, 2013). This data was converted to an SES variable 
such that Low SES reflected the highest percentages of FRPL (75.1 % - 100%), Med-low 
reflected 50.1 – 75% FRPL, Med-high reflected 25.1 – 50% FRPL, and High SES 
reflected the lowest percentages of FRPL (0 – 25%).

**Teacher characteristic: Experience.** A teacher-level variable of teacher 
“experience” was used that was purely numerical. Question 401 of the AIRS 2019 simply 
asked teachers how many years they worked as a teacher, to which they entered a
numeric value. The value was standardized to aid in model calculation.

**Feature characteristic: Feature choice.** A feature-level variable came from question 608 of the AIRS 2019 (see Figure 4) that provided teachers with a filtered list of only the curriculum materials that they had already reported using often on previous survey questions, including question 604. The question then gave three checkbox options in columns asking whether *each* curriculum material was “required” by their district or school, “recommended,” or “neither.”

**Figure 4**

*Question 608 from AIRS 2019*

Of the mathematics curricula and digital materials you indicated using regularly, please indicate which are provided by your district or school, either as a requirement or recommendation.

<table>
<thead>
<tr>
<th>MATERIALS SELECTED IN ( air_t_cmm_601_m OR air_t_cmm_602_m OR air_t_cmm_603_m ) AND air_t_cmm_604_a</th>
<th>Required by my district or school</th>
<th>Recommended by my district or school but not required</th>
<th>Neither required nor recommended by my district or school</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td></td>
</tr>
</tbody>
</table>

Originally, I planned for this feature-level variable to have three levels: 2 – at least one program containing the feature of interest the teacher marked as “required” by their school or district, 1 – at least one program containing the feature of interest the teacher marked as “recommended” but none were required, and lastly, 0 – none of the programs containing the feature of interest were neither required nor recommended (“neither”). However, this variable came with difficult decisions because teachers were
only asked about programs that they already marked they use often. This left a large amount of data either missing or left for me to presume. For example, if a teacher did not mark any programs containing the feature “adaptive,” I either had to leave this access data blank or I must assume that none of the programs that do contain the “adaptive” feature were required or recommended. This was very unlikely, especially for programs that districts or schools may have recommended. As a result, rather than having so much missing data, I chose to remove the “recommended” portion of this question such that there were only two levels: 1 – yes choice – no programs containing the feature were required; or 0 – no choice - at least one program containing the feature was required. This still left me to presume a great deal. In the same example used earlier, if a teacher did not mark that they used any programs containing the feature “adaptive” then I was left to presume that none of those programs were required. Although this was not ideal, it prevented the loss of data to a significant amount.

Dependent Variable: Access to Feature

Unlike other variables used in the study, the dependent variable, “access” to feature, required several stages to create it. I used the data from question 604 (see Figure 2) of the AIRS 2019 and combined this information with the categorization of programs by feature. Recall that these questions on the survey presented teachers with a list of programs (e.g., Dreambox or Reflex) and two checkboxes for which they were asked to mark all programs that were used once a week or more either by students during class or by the teacher in or out of class (RAND American Educator Panels, 2019, pp. 29–31). First, I collapsed the two parts of question 604 that had separate checkboxes to clarify
how the program was used to simply reflect all programs that were used often. Access was defined as endorsement in at least one of the two categories of use.

Categorizing these programs by the six chosen features (e.g., instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access) then allowed me to collapse the program level so that in the final dataset, each teacher had six rows of data, one row for each feature. In this configuration, the “access” variable reported 0 for “No” or a 1 for “Yes” to indicate whether each teacher had access to each feature. For example, each teacher had a row for the feature indicator “videos” and then for the “access” variable each teacher was assigned a 0: “No” if neither they or their students use any programs from the list that contain instructional videos, and a 1: “Yes” to indicate that the teacher used at least one program often (either for them or their students) that contained instructional videos.

**Descriptive Percentages and Null Model for Research Question #1**

To answer the first research question, I computed descriptive statistics, including means and standard deviations, for each of the independent variables. Additionally, I computed the percentages of teachers who had access to each of the six features (e.g., instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access). I also calculated percentages for subgroups of the populations based on the school, teacher, and feature characteristics. Then, I began the process of calculating a multilevel logistical regression analysis by calculating a null model. I used results from this null model to answer the first research question by
providing predicted probabilities that a teacher would have access to each of the six
features of interest.

**Multilevel Logistical Regression Model for
Research Question #2**

The analysis for research question 2 focused on examining the school, teacher,
and feature characteristics. I conducted a 2-level generalized multilevel logistical
regression model (GLMM). In Fall 2020, I created a dummy dataset and used it to pilot
some of the analysis techniques. From this process I learned how to execute all analyses
using R and gained a greater understanding of the analysis method itself. The model was
multilevel so that the model would consider the nested nature of features within each
teacher. The model was logistic in that the outcome variable was binary to indicate
whether or not (1 = yes, 0 = no) each feature was available in at least one of the programs
the teacher reported using often. Each of the six features (sample of microunits of level 1)
were nested within each teacher (sample of mesounits of level 2). Predictor variables
included characteristics of each school (level 2: grade band, SES), teacher (level 2:
experience), and feature (level 1: feature id and choice).

The GLMM predicted the probability that each feature type was in a program that
was in use, and I further explored (via interactions) if these probabilities differed based
on the characteristics involved for school, teacher, and feature characteristics. For
example, for the feature “videos,” I determined the likelihood that a novice elementary
teacher who teaches at a low-income school reported using at least one program weekly
that was suggested by the school and had access to instructional videos, while controlling
for lack of independence of features used by the same teachers. I tabulated and visualized these probabilities to aid in interpretation. I performed all analyses using R 4.2.1 (R Core Team, 2021). The *lme4* 1.1-30 package was used to calculate the model (Bates et al., 2015). The full reproducible code is provided in Appendix D and Appendix E.

Multilevel logistical regression models are calculated using maximum likelihood estimation methods. These methods involve iterative calculations that give estimated predictors that get closer and closer to the “true” model and then converge once the predictors are considered mathematically “close enough.” Variations in these methods typically converge to the same results, and the *glmer* function in the *lme4* package explicitly allows the user to specify different optimizers to assist with convergence problems (Bates et al., 2015, 2015; Brauer & Curtin, 2018). The package also includes the function *allFit()* to run multiple optimizers consecutively to see which converge.

**Assumptions**

According to Mehmetoglu and Jakobsen (2016), there are four specific assumptions that must be met for logistic regression to be considered unbiased and sufficient: (1) the logit of the dependent variable is a linear function of the independent variables, (2) no important variables are left out and no unnecessary variables are included, (3) independence of observations, and (4) there is no multicollinearity among independent variables. This section will address each of these assumptions and either acknowledge each as a limitation or describe how each assumption was addressed.

Logistic regression requires linearity between continuous independent variables
and log odds. This assumption was checked by visually inspecting these relationships in a scatterplot for each continuous variable (Mehmetoglu & Jakobsen, 2016). Each variable was assessed individually, and decisions were made whether to transform the variable or to disregard it altogether.

Second, the assumptions that no important variables are missing from the model and no extraneous variables are included is a matter of theory (Mehmetoglu & Jakobsen, 2016). Strong theoretical arguments have been made for each variable throughout this dissertation such that the model is sufficiently grounded.

Third, independence of observations is an assumption that was addressed by using a multilevel model. By nature, multilevel models take into account the nested nature of the observations, no longer requiring a need for the observations to be independent of each other (Hox et al., 2017; Osborne, 2015). We expect teachers within the same school to have similar access to features and, therefore, the multilevel nature of the model considers the nested nature of program features contained within different teachers, contained within different schools. RAND did not provide any indicators regarding teachers working in the same school; thus, we must treat our teachers as being independent of each other.

Last, logistic regression assumes little to no multicollinearity between independent variables. This assumption was assessed by computing variance inflation factors (VIF; (Midi et al., 2010). An independent variable with a VIF value that exceeds 5 would have been removed from consideration in the model.

Conclusion
In this chapter, I described the methods and research design that was used to best determine the relationship between teachers’ access to features and other contextual characteristics (e.g., school, teacher, and feature characteristics). I used an existing AIRS 2019 dataset for which teachers reported using specific programs, reanalyzed by breaking each program down by its containing features. This allowed me to answer the research questions by reporting the most common features teachers have access to using basic descriptive statistics and percentages, as well as a multilevel logistic regression model to determine the likelihood of a teacher with different characteristics having access to each of the six features.
CHAPTER IV

RESULTS

The purpose of this study was to explore what features are present within digital mathematics curriculum resources that teachers report using often. In this chapter, I describe the results of the descriptive statistics and multilevel modeling analyses. First, I give descriptive statistics for the data to better understand the data in general. Then I present five main results of the study. The first result is presented in two parts. Result 1 Part 1 aligns with the first research question, using descriptive statistics and the null model. Next, I describe the data analysis journey to the final model, including some preliminary analysis, and I present the final multilevel logistical regression model. Then, I describe Result 1 Part 2 which aligned with the second research question and simply confirmed the result found for the first research question. Then, I present Results 2 – 5 which all aligned with the second research question. The chapter concludes with a summary of the findings.

Descriptive Statistics

As seen in Table 2 there were 1,014 elementary teachers, 458 middle school teachers, and 392 high school teachers. The data included many more elementary teachers than middle or high school. In fact, elementary teachers made up over half (54.3%) of the dataset.

The percentage of students in a school who qualify for free and reduced-priced
Table 2

Descriptive Statistics: Grade Band, SES, and Teacher Experience

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total N = 1,864</th>
<th>Elementary school N = 1,014</th>
<th>Middle school N = 458</th>
<th>High school N = 392</th>
</tr>
</thead>
<tbody>
<tr>
<td>School SES(^a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High (0-25% FRPL)</td>
<td>428</td>
<td>23.0</td>
<td>199</td>
<td>110</td>
</tr>
<tr>
<td>Med-high (25-50% FRPL)</td>
<td>664</td>
<td>35.6</td>
<td>336</td>
<td>164</td>
</tr>
<tr>
<td>Med-low (50-75% FRPL)</td>
<td>468</td>
<td>25.1</td>
<td>271</td>
<td>114</td>
</tr>
<tr>
<td>Low (75-100% FRPL)</td>
<td>304</td>
<td>16.3</td>
<td>208</td>
<td>70</td>
</tr>
<tr>
<td>Teacher experience (yrs)</td>
<td>14.45</td>
<td>8.23</td>
<td>14.55</td>
<td>8.21</td>
</tr>
</tbody>
</table>

Note. Error bars reflect 95% confidence intervals.

\(^a\)SES captures the percent of FRPL at the teachers’ school.

lunch (FRPL) was given as a four-level variable which was not evenly distributed. Most teachers (35.6%) were in schools in the second highest-income category (25-50% FRPL), and the low-income category (75-100% FRPL) was the smallest (16.3%). A closer look at Table 2 reveals that SES was not the same across grade band. Almost 60% of middle school teachers in the sample worked in a higher income school and only 6.6% of high school teachers in the sample worked in a low-income school. Through the process of analysis, this variable eventually collapsed to two levels to aid in the convergence of some of the more complicated models. Justification for this decision will be given later.

Teacher Experience was a numerical variable ranging from 1 to 47 years with an average of 14.45 years. As can be seen in, Table 2 the average years of experience of
teachers was about the same across all grade bands. The histogram in Figure 5 shows that teacher experience was skewed right with more teachers with less experience and then experience gradually tapers off.

**Figure 5**

*Histogram of Teacher Experience*

Research Question #1: Result 1 Part 1

The first research question focused on the six features most commonly present within digital mathematics curriculum resources that teachers report using often. To answer this research question, I ran descriptive statistics and calculated percentages to reflect the proportion of teachers who have access to each of the six features in at least one program that they report using often. These counts and percentages are reported in Table 3. In addition, I started the process of calculating a multilevel logistic regression by calculating a null model. This null GLMM model included only the dependent variable of
access to feature, feature type as a main fixed effect, and random intercepts for each teacher. The random intercepts allowed the model to consider the lack of independence between features pertaining to the same teacher. The output of this null model gave predicted probabilities that a teacher in this sample would have access to each of the six features of interest, prior to considering other school, teacher, and feature characteristics. These probabilities are also presented in Table 3.

Table 3
Counts, Percents, and Predicted Probabilities of Teachers’ Access to Feature

<table>
<thead>
<tr>
<th>Feature</th>
<th>Observed</th>
<th>Null GLMM predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Percent</td>
</tr>
<tr>
<td>Practice problems</td>
<td>1,527</td>
<td>81.9</td>
</tr>
<tr>
<td>Instructional Videos</td>
<td>1,367</td>
<td>73.3</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>1,236</td>
<td>66.3</td>
</tr>
<tr>
<td>Parent data access</td>
<td>1,068</td>
<td>57.3</td>
</tr>
<tr>
<td>Interactive scenarios</td>
<td>1,060</td>
<td>56.9</td>
</tr>
<tr>
<td>Adaptive</td>
<td>972</td>
<td>52.1</td>
</tr>
</tbody>
</table>

*Note. Predicted probabilities are for an average teacher. N = 1,864 teachers.*

Based on teachers reporting which programs they use often (at least once a week or more), as shown in Table 3, Practice problems (81.9%) were the most common feature found in at least one program teachers reported using. Instructional Videos (73.3%) were the second most common feature. The Practice problems and instructional Videos features also had the highest predicted probabilities that a teacher had access to ($P = .902$, $P = .931$). These observed percentages can also be seen visually in Figure 6. Practice
problems include traditional textbook style questions where the program provides feedback on the correctness of the answer. instructional Videos include any video that teaches mathematical content. It is not surprising that these two are the most common features because Practice problems and Videos are both features that can be the main focus of an instructional program in mathematics, but they can also be added on as supplementary materials. For example, the main focus of Khan Academy is their instructional Videos, but over time they have added Practice problems to supplement many of their videos so that students can test their understanding of the content shown in the videos.

**Figure 6**

*Observed Percent of Feature Access*

*Note*. Error bars reflect 95% confidence intervals.
The least common feature was Adaptive (52.1%), which also had the lowest predicted probability (.520). This was surprising to me, but only because my personal anecdotal experience with these kinds of programs has been that they seem quite popular. Adaptive means that the program assigns content based on a built-in assessment. There are many possible reasons that this feature might be less common. Perhaps Adaptive programs cost more, and so fewer schools are able to get funding to use them. Another reason might be that when a program contains the Adaptive feature this inherently makes it more difficult for the program to include the create/revise content feature. Perhaps these are both lower because teachers are simply forced to choose between these two features.

This result helps to reveal which features were most common, rather than simply reporting a list of programs teachers use in mathematics. This gives us deeper insight as to what was happening with the digital mathematics curriculum resources in classrooms overall.

**Research Question #2**

The second research question focused on relationships between teachers’ access to six chosen features of digital mathematics curriculum resources and (a) school characteristics (e.g., grand band, SES), (b) teacher characteristics (e.g., experience), and (c) feature characteristics (e.g., feature choice). In this section, I examine teachers’ feature access within different subgroups of the population based on school, teacher, and feature characteristics. For example, do teachers in low-income schools have a different
likelihood of access to each feature than teachers in high-income schools? This section continues to describe the analysis process for calculating the multilevel logistic regression model. The process involved calculating several models in progression and comparing each model to the previous one. I began by calculating the null model GLMM which was described in the previous section. Next, I calculated a full model with all independent variables of interest. Subsequently I dropped the choice predictor and explored interactions. Lastly, this section describes the final model, all of its parameter estimates, and an interpretation of the model.

**Note on Weights**

The dataset as given from RAND included weighting variables for each teacher to adjust the data to make it a nationally representative sample. However, this proved too complex for this analysis. There is no R code (to my knowledge) that computes a multilevel logistic GLMM that also includes a way to use sample weights. Calculations are possible in theory, but the implementation simply does not exist yet. Consequently, the model cannot be generalized to represent the entire population of the U.S., but it is still likely that similar trends would be present.

**Journey to the Final Model**

The journey toward the final model was long. A multilevel logistic regression model is complex, especially when containing a 3-way interaction. I calculated and recalculated all of the models several times over to correct mistakes, but also to get them to converge (selection of technical optimization specifications). Although there were
several runs through each model, I will only describe two: one that led to dropping the choice variable and collapsing SES, and the final pass through. All other runs were to correct mistakes in the models.

I conducted further preliminary analysis to look at the observed relationships between these variables. The first thing to notice in Figure 7 is that only 10.7% of high school teachers reported using an Adaptive program, making this feature the least common. Additionally, elementary school teachers appear to use more Interactive programs than middle or high school teachers. Most importantly, the gaps between the grade band lines appear inconsistent such that the lines are not parallel. Therefore, there

**Figure 7**

*Observed Percent of Feature Access by Grade Band*

![Observed Percent of Feature Access by Grade Band](image)

*Note.* Error bars reflect 95% confidence intervals.
was a possible interaction between grade band and feature type that proved worth exploring in the final model.

In addition to a suspected interaction between feature type and grade band, preliminary analysis also led to suspicions that this interaction could also include SES. This would make a three-way interaction between feature type, grade band, and SES. A three-way interaction would result in a rather complex model, but one that would reflect the relationships among these variables and not just their main effect on the dependent variable.

The interaction models also gave warnings that they would not converge. With a six-level Feature variable, a three-level Grade Band variable, and a four-level SES variable, the 3-way interaction model proved far too complex. Therefore, based on preliminary analysis (specifically in Figure 8), I decided to collapse the SES variable to two levels rather than four. Looking across all feature panels, you will see that, for most features, the top two SES lines (Low, Med-low) follow a similar path while the bottom two SES lines (Med-high, High) also follow a similar path to each other. The only cases where this is not clear are for the Low SES line for the Interactive feature and Practice feature. This also justifies suspicion for the three-way interaction. Therefore, with so many features following such a pattern, I attempted the two-level SES, and it proved not only significant, but just what the models needed to finally converge. Consequently, some detail was lost, but the model would still capture the relationships.

Full Model

Once I calculated and interpreted the null model, I then calculated a full model
which included main effects for all possible predictors (e.g., Feature Type, SES, Grade Band, Teacher Experience, and Feature Choice) as fixed effects and the random intercept to take nesting into account. This model had a difficult time converging. In order to assist in convergence, first I standardized the teacher experience variable. Additionally, I attempted several optimizing methods (using the allFit function from the lme4 package) to aid the model to converge. I selected the bobyqa optimizer (Bates et al., 2022; Powell,
and used this successfully on all models in the final run-through.

A comparison of this full model with the null model was shown to be statistically significant (when assessed via a likelihood-ratio test, $X^2(5, N = 11,166) = 1747.7, p < .001$). A quick glance at the Wald-like $t$ test for parameter estimates showed that Grade Band and Teacher Experience looked promising for significance, while SES and Feature Choice did not. Although it is possible that SES was not a statistically significant main effect, based on preliminary analysis, the variable was retained to test its significance when included in a 3-way interaction.

**Linearity of Experience and Logit**

To address the assumption that continuous independent variables have a linear relationship with the log odds, this relationship was put into a scatterplot (see Figure 9). This relationship does appear to be linear and thus the assumption is met (Mehmetoglu & Jakobsen, 2016).

**Variance Inflation Factors**

Next, to address the assumption that there may be little to no multicollinearity between independent variables, I calculated Variance Inflation Factors (VIF) on each predictor (see Table 4). This is an important requirement for multilevel logistic regression models (Mehmetoglu & Jakobsen, 2016; Midi et al., 2010). All VIFs were approximately 1, which is less than 5 and, therefore, none were removed from the model for violating this assumption.
Table 4

*Generalized Variance Inflation Factors*

<table>
<thead>
<tr>
<th>Variable</th>
<th>GVIF</th>
<th>Df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature</td>
<td>1.009</td>
<td>5</td>
</tr>
<tr>
<td>Socioeconomic status</td>
<td>1.026</td>
<td>1</td>
</tr>
<tr>
<td>Grade band</td>
<td>1.032</td>
<td>2</td>
</tr>
<tr>
<td>Teacher experience</td>
<td>1.003</td>
<td>1</td>
</tr>
<tr>
<td>Feature choice</td>
<td>1.000</td>
<td>1</td>
</tr>
</tbody>
</table>

Drop Choice

Based on the likelihood-ratio test $X^2(1, N = 11,166) = 1557, p < .001$, feature choice was a statistically significant main effect. However, keeping this variable made
further analysis too complex, and brought the use of this variable into question. Because this survey question was *only* asked for programs that teachers reported using, that left me to assume that if the feature was not in any of those programs, then the programs that do contain that feature were not “required” (see the Variables section in Chapter IV). As seen in Table 5, this left me with exactly 0 teachers who had “No” for both “access” and “choice.” In other words, even though it is likely that there were at least some teachers who were *not* using programs that were required, my dataset could not contain this information. This caused quasi-separation in the data which caused maximum likelihood estimation of the model to fail (Rainey, 2016). Although some researchers advocate for retaining these variables and finding other estimation methods, I chose to drop the variable, because these difficulties derived from my artificial (and somewhat inaccurate) information to begin with.

**Table 5**

*Choice Variable Near-Separability*

<table>
<thead>
<tr>
<th>Access</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Yes</td>
<td>3,954</td>
<td>100</td>
</tr>
<tr>
<td>Yes</td>
<td>2,061</td>
<td>28.5</td>
</tr>
</tbody>
</table>

Therefore, I removed “choice” from the model, and to compare it with the null model, both this model and the null model was recalculated on a dataset that re-included three teachers who had been dropped due to missing data for the choice variable. Since the choice variable was dropped, these teachers could now be included. I recalculated the
mean and standard deviation of experience to re-standardize that variable for use in these models. This Drop Choice model was still statistically significantly better than the null model \(X^2(4, N = 11,184) = 190.23, p < .001\).

**Two-Way Interaction**

Based on preliminary visualizations, it seemed likely that an interaction might exist. The next model included an interaction between feature type and grade band as fixed main effects. SES (two-level) and teacher experience as fixed main effects and the random intercept were also included. This model was shown to be a better fit than the Drop Choice model using the likelihood-ratio test \(X^2(10, N = 11,184) = 461.43, p < .001\).

Although the full model would converge with the choice variable included, this model would not. I attempted nine different optimizers (using the function `allFit` from the `lme4` package) without success. As described previously, even with SES collapsed to two levels, this model still would not converge when the choice variable was included. Once SES was collapsed to two levels and choice was dropped, this model converged.

**Final Model: Three-way Interaction**

Lastly, I considered three-way interactions between feature type, grade band, and SES with teacher experience as fixed main effects and the random intercept. This was shown to be the best fit model based on the likelihood ratio test \(X^2(17, N = 11,166) = 41.09, p = .0009 < .001\). Parameters for the final model can be found in Table 6. Estimates \((b, SE, p)\) are given and then are given exponentiated as odds-ratios to make
Table 6

**Final Model Parameter Estimates**

<table>
<thead>
<tr>
<th>Fixed effects</th>
<th>$b$</th>
<th>SE</th>
<th>$p$</th>
<th>OR</th>
<th>[95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.12</td>
<td>.16</td>
<td>&lt;.001***</td>
<td>8.29</td>
<td>[6.05, 11.36]</td>
</tr>
<tr>
<td>Experience (years)</td>
<td>-0.18</td>
<td>.05</td>
<td>&lt;.001***</td>
<td>0.84</td>
<td>[0.76, 0.93]</td>
</tr>
<tr>
<td>Feature (reference = Videos)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactive</td>
<td>-1.20</td>
<td>.17</td>
<td>&lt;.001***</td>
<td>0.30</td>
<td>[0.21, 0.42]</td>
</tr>
<tr>
<td>Practice</td>
<td>0.70</td>
<td>.20</td>
<td>&lt;.001***</td>
<td>2.02</td>
<td>[1.35, 3.01]</td>
</tr>
<tr>
<td>Adaptive</td>
<td>-0.80</td>
<td>.18</td>
<td>&lt;.001***</td>
<td>0.45</td>
<td>[0.32, 0.64]</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>-1.13</td>
<td>.17</td>
<td>&lt;.001***</td>
<td>0.32</td>
<td>[0.23, 0.46]</td>
</tr>
<tr>
<td>Parent</td>
<td>-1.47</td>
<td>.17</td>
<td>&lt;.001***</td>
<td>0.23</td>
<td>[0.16, 0.32]</td>
</tr>
<tr>
<td>Grade Band (reference = Elementary)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle school</td>
<td>-0.92</td>
<td>.26</td>
<td>&lt;.001***</td>
<td>0.40</td>
<td>[0.24, 0.66]</td>
</tr>
<tr>
<td>High school</td>
<td>-1.94</td>
<td>.25</td>
<td>&lt;.001***</td>
<td>0.14</td>
<td>[0.09, 0.23]</td>
</tr>
<tr>
<td>SES*: High vs. Low</td>
<td>0.08</td>
<td>.23</td>
<td>.734</td>
<td>1.08</td>
<td>[0.68, 1.71]</td>
</tr>
<tr>
<td>Feature x Grade Band</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactive x Middle</td>
<td>-0.57</td>
<td>.29</td>
<td>.049*</td>
<td>0.57</td>
<td>[0.32, 1.01]</td>
</tr>
<tr>
<td>Practice x Middle</td>
<td>0.43</td>
<td>.33</td>
<td>.195</td>
<td>1.53</td>
<td>[0.80, 2.94]</td>
</tr>
<tr>
<td>Adaptive x Middle</td>
<td>-1.11</td>
<td>.29</td>
<td>&lt;.001***</td>
<td>0.33</td>
<td>[0.19, 0.59]</td>
</tr>
<tr>
<td>Create/Revise x Middle</td>
<td>0.58</td>
<td>.29</td>
<td>.044*</td>
<td>1.78</td>
<td>[1.01, 3.16]</td>
</tr>
<tr>
<td>Parent x Middle</td>
<td>0.70</td>
<td>.29</td>
<td>.014*</td>
<td>2.02</td>
<td>[1.14, 3.56]</td>
</tr>
<tr>
<td>Interactive x High</td>
<td>0.67</td>
<td>.28</td>
<td>.015*</td>
<td>1.96</td>
<td>[1.13, 3.39]</td>
</tr>
<tr>
<td>Practice x High</td>
<td>-0.01</td>
<td>.30</td>
<td>.973</td>
<td>0.99</td>
<td>[0.55, 1.79]</td>
</tr>
<tr>
<td>Adaptive x High</td>
<td>-2.75</td>
<td>.34</td>
<td>&lt;.001***</td>
<td>0.06</td>
<td>[0.03, 0.13]</td>
</tr>
<tr>
<td>Create/Revise x High</td>
<td>2.05</td>
<td>.28</td>
<td>&lt;.001***</td>
<td>7.74</td>
<td>[4.42, 13.56]</td>
</tr>
<tr>
<td>Parent x High</td>
<td>1.04</td>
<td>.28</td>
<td>&lt;.001***</td>
<td>2.82</td>
<td>[1.63, 4.86]</td>
</tr>
<tr>
<td>Feature x SES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactive</td>
<td>0.18</td>
<td>.26</td>
<td>.492</td>
<td>1.19</td>
<td>[0.72, 1.99]</td>
</tr>
<tr>
<td>Practice</td>
<td>0.15</td>
<td>.30</td>
<td>.613</td>
<td>1.17</td>
<td>[0.64, 2.12]</td>
</tr>
<tr>
<td>Adaptive</td>
<td>-0.29</td>
<td>.26</td>
<td>.270</td>
<td>0.75</td>
<td>[0.45, 1.26]</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>-0.03</td>
<td>.26</td>
<td>.896</td>
<td>0.97</td>
<td>[0.58, 1.61]</td>
</tr>
<tr>
<td>Parent</td>
<td>-0.35</td>
<td>.26</td>
<td>.167</td>
<td>0.70</td>
<td>[0.42, 1.16]</td>
</tr>
<tr>
<td>Grade Band x SES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>1.15</td>
<td>.42</td>
<td>.006**</td>
<td>3.16</td>
<td>[1.37, 7.27]</td>
</tr>
<tr>
<td>High</td>
<td>-0.04</td>
<td>.43</td>
<td>.929</td>
<td>0.96</td>
<td>[0.41, 2.24]</td>
</tr>
<tr>
<td>Feature x Grade Band x SES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactive x Middle</td>
<td>-0.89</td>
<td>.47</td>
<td>.057</td>
<td>0.41</td>
<td>[0.16, 1.04]</td>
</tr>
<tr>
<td>Practice x Middle</td>
<td>-0.49</td>
<td>.55</td>
<td>.374</td>
<td>0.61</td>
<td>[0.20, 1.83]</td>
</tr>
<tr>
<td>Adaptive x Middle</td>
<td>0.68</td>
<td>.47</td>
<td>.146</td>
<td>1.98</td>
<td>[0.78, 5.02]</td>
</tr>
</tbody>
</table>

*(table continues)*
### Fixed effects

<table>
<thead>
<tr>
<th></th>
<th>$b$</th>
<th>$SE$</th>
<th>$p$</th>
<th>OR</th>
<th>[95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create/Revise x Middle</td>
<td>-0.33</td>
<td>0.47</td>
<td>0.490</td>
<td>0.72</td>
<td>[0.28, 1.84]</td>
</tr>
<tr>
<td>Parent x Middle</td>
<td>0.30</td>
<td>0.47</td>
<td>0.522</td>
<td>1.35</td>
<td>[0.53, 3.45]</td>
</tr>
<tr>
<td>Interactive x High</td>
<td>-0.18</td>
<td>0.48</td>
<td>0.711</td>
<td>0.84</td>
<td>[0.32, 2.17]</td>
</tr>
<tr>
<td>Practice x High</td>
<td>0.11</td>
<td>0.52</td>
<td>0.828</td>
<td>1.12</td>
<td>[0.40, 3.14]</td>
</tr>
<tr>
<td>Adaptive x High</td>
<td>0.81</td>
<td>0.57</td>
<td>0.152</td>
<td>2.25</td>
<td>[0.73, 6.89]</td>
</tr>
<tr>
<td>Create/Revise x High</td>
<td>0.14</td>
<td>0.50</td>
<td>0.774</td>
<td>1.15</td>
<td>[0.43, 3.09]</td>
</tr>
<tr>
<td>Parent x High</td>
<td>0.02</td>
<td>0.48</td>
<td>0.960</td>
<td>1.02</td>
<td>[0.40, 2.65]</td>
</tr>
</tbody>
</table>

*Note.* Sample includes 1,864 teachers for each of 6 feature types for a total of 11,184 observations.

Variation of feature uniqueness within teacher is estimated to be 3.375 (random effect).

*SES captures the percent of free or reduced-price lunch (FRPL) at the teacher’s school. High = FRPL > 50%, Low = FRPL <50%.

*p < .050.** p < .010.*** p < .001.

...them easier to interpret. Each parameter in the odds-ratio column tells us how many times more likely access is in general, holding all other parameters constant, while considering nesting. For example, for every year increase in teacher Experience, a teacher has 0.84 times lower odds of having access to the features. In other words, teachers with more experience have a lower likelihood of having access to the features. This is likely just due to the relationship between teacher age and technology use, but these things were not the focus of this study.

The rest of the parameters come from the 3-way interaction between Feature Type, Grade Band, and SES, which are so interconnected that the results are best explained visually as in Figure 10. With probability of Access on the y-axis, this figure provides a panel for each Feature, a line for each SES level and puts Grade Band on the x-axis. The individual points represent the probability that a teacher, in the specified grade band and SES level, has Access to each feature. Each of these probability values are provided in Table F-1 in Appendix F.
Figure 10

Predicted Probability for Access to Feature: Interaction Effects

Note. Error bars reflect 95% confidence intervals. * represents p < .001***.

SES captures the percent of free or reduced-price lunch (FRPL) at the teachers’ school: High SES = FRPL < 50%, Low SES = FRPL > 50%

*p < .050. **p < .010. ***p < .001.

To explore this 3-way interaction further, I conducted post-hoc analysis to compare these probabilities. First, I conducted feature-to-feature comparisons to see which of the six features were significantly different from each other. With 15 feature comparisons, two SES levels, and three Grade Bands, this produced a total of 90 p-values which can all be
found in Table F-2 in Appendix F. For purposes of discussion, Table 7 contains just an excerpt of Table F-2. Next, I conducted further post-hoc analysis of these probabilities to find significant differences in Grade Band (see Table F-3 for p values) and SES (see Table F-4 for p values). With these p-values provided in Appendix F, these differences are best explained visually. To this end, I included these p values in Figure 10, Figure 11, and Figure 12 with the symbol ★ used to represent \( p < .001 *** \). Figure 11 and Figure 12 are simply duplicates of Figure 10 that will be shown and discussed later in this section, with Figure 11 emphasizing Grade Band differences and Figure 12 emphasizing SES differences.

**Table 7**

*Excerpt of Table F-2 Showing Feature-to-Feature Comparisons of Predicted Probability of Access within SES, by Grade Band*

<table>
<thead>
<tr>
<th>Feature contrast</th>
<th>SES</th>
<th>Elementary</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice - Interactive</td>
<td>Low</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
</tr>
<tr>
<td>Practice - Adaptive</td>
<td>Low</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
</tr>
<tr>
<td>Videos - Interactive</td>
<td>Low</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
<td>( p = .638 )</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
<td>( p = .136 )</td>
</tr>
<tr>
<td>Videos - Adaptive</td>
<td>Low</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
<td>( p &lt; .001 *** )</td>
</tr>
</tbody>
</table>

*Note.* SES captures the percent of free or reduced-price lunch (FRPL) at the teacher’s school: High SES = FRPL < 50%, Low SES = FRPL > 50%

\*\( p < .050 \), \*\( p < .010 \), \*\*\( p < .001 \).

Significant p values are bold for emphasis.

This analysis produced five main results pertaining to the second research.
question, all of which stemmed from difference comparisons within each of the three aspects of the 3-way interaction: Feature, Grade Band, and SES. The first result came from feature-to-feature comparisons and simply confirmed the result from the first research question. Therefore, I call it Result 1 Part 2. Results 2 and 3 both came from an analysis of grade band trends. Result 4 came from an analysis of SES comparisons. Lastly, Result 5 came from looking at each feature individually for further insight. This result focused only on the Parent data access feature.

**Result 1 Part 2: Feature-to-Feature Comparisons**

As a product of the post-hoc analysis of significant differences comparing the probability of each of the six features to each other, 90 $p$ values were calculated (see Table F-2) to compare features within each Grade Band and SES level. For explanation purposes, Table 7 includes only an excerpt of Table F-2 to illustrate Result 1 Part 2.

Table 7 and Table F-2 show that Practice problems and instructional Videos are significantly more likely than Interactive and Adaptive features for 22 of the 24 combinations of Grade Band and SES. For example, on the first row of Table 7, in the first column we see that for teachers in Low SES elementary schools, Practice problems are significantly more likely than Interactive scenarios ($p < .001^{**}$). Recall that the result from the first research question, Result 1 Part 1, was that Practice problems and instructional Videos were more common and more likely than Interactive scenarios and Adaptive features. This result, Result 1 Part 2, from the second research question, confirms that result by showing that Practice problems and instructional Videos are significantly more likely than Interactive and Adaptive features and this remains true.
even when we consider different SES and Grade Band situations. As seen in the last column of the third row of Table 7, the two \( p \) values that were not significant were in comparison between Videos and Interactive for high school teachers.

**Result 2 and 3: Grade Band Comparisons**

The second result applies to five of the six features, and the third result applies to that sixth feature only. Focusing on the emphasized Grade Band comparisons, Figure 11 shows that for five features (i.e., Videos, Interactive, practice, Adaptive, and Parent) elementary teachers are significantly more likely to have access than high school teachers. For example, at the top left, the probability that a teacher uses at least one program often that contains Videos is high for elementary school teachers (Low SES: \( P = .900 \); High SES: \( P = .892 \)), but statistically significantly (\( p \)’s < .001) declines for high school teachers (Low SES: \( P = .553 \); High SES: \( P = .421 \)). For elementary school teachers, it depends on their school’s SES status. Recall that these individual probability values (the points themselves) can be found in Table F-1 in Appendix F.

Result 3 highlights the fact that the ability to Create and/or Revise content within digital programs remains consistently around 0.75 for elementary and high school teachers regardless of SES. This is the only feature with a relatively high probability for high school teachers. This result indicates that Low SES middle school teachers (\( P = .819 \)) are statistically significantly more likely to have access to programs that allow them to Create and/or Revise content than High SES elementary school teachers (\( P = .656; p = .007 < .010^{**} \)).
Figure 11

Predicted Probability for Access to Feature: Interaction Effects with Emphasis on Grade Band Differences

Note. Error bars reflect 95% confidence intervals. • represents \( p < .001 \).  

*SES captures the percent of free or reduced-price lunch (FRPL) at the teachers’ school: High SES = FRPL < 50%, Low SES = FRPL > 50%  

\( *p < .050. **p < .010. ***p < .001. \)

Result 4: SES Comparisons

In Figure 12, with emphasis on SES comparisons, we see that teachers in Low SES elementary schools have a statistically significantly higher probability of feature
Figure 12

*Predicted Probability for Access to Feature: Interaction Effects with Emphasis on SES Differences*

<table>
<thead>
<tr>
<th></th>
<th>Videos</th>
<th>Interactive</th>
<th>Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

Note. Error bars reflect 95% confidence intervals. ◆ represents p < .001***.

SES captures the percent of free or reduced-price lunch (FRPL) at the teachers’ school: High SES = FRPL < 50%, Low SES = FRPL > 50%.

* p < .050. ** p < .010. *** p < .001.

Access than teachers in High SES elementary schools. For example, looking at the top left panel, teachers in Low SES (> 50% FRPL) elementary schools are statistically significantly more likely to have Access to Videos (P = .919) than those in High SES
elementary schools ($P = .767; p < .001^{***}$). This trend is true across all features except one: Interactive ($p = .088$). However, recall in Figure 8 that the Interactive feature was the only feature that did not fit the pattern when collapsing SES from four levels to two levels. The Low SES (>75% FRPL) line on that graph is higher for elementary school as well. This leaves me confident that if the four-level interaction had converged it likely would have achieved significance for this feature as well.

**Result 5: Parent Data Access**

As can been seen in Figure 10, in the bottom right panel, the feature of having Parent Access to Data statistically significantly declines from elementary to High school for both levels of SES, but for middle school teachers, it depends. Teachers in Low SES elementary schools ($P = .832$) are statistically significantly more likely to have access to this feature than teachers in Low SES elementary schools ($P = .591; p < .001$). This trend is significant because it is the only positive trend across grade band.

**Conclusion**

Results from this analysis shed light on many aspects in regard to teachers’ access to six features and their relationship to school and teacher characteristics. Results of this analysis were five-fold: (1) Teachers were significantly more likely to use programs that contain Practice problems and instructional Videos than Interactive scenarios and Adaptive features, even for almost all combinations of Grade Band and SES. (2) For five features, elementary teachers are more likely to use programs with those features than high school teachers, but (3) high school teachers are just as likely to use programs with
the Create/Revise feature. (4) No significant SES differences were found for elementary or high school teachers, but for elementary school teachers, it depends on SES; Teachers in Low SES elementary schools are more likely to use programs that contain all features than teachers in High SES elementary schools. (5) Teachers in Low SES elementary schools are more likely to use programs that contain the ability for Parent to Access Data than teachers in Low SES elementary schools. These results have great significance in the field which will be discussed in the final chapter.
CHAPTER V
DISCUSSION

The purpose of this dissertation was to understand which school, teacher, and feature characteristics contributed to teachers’ access to features within digital curriculum resources for mathematics instruction. The research questions in this study focused on which of six features most commonly present within digital mathematics curriculum resources that teachers report using often, and relationships between teachers’ access to the features and school characteristics, teacher characteristics and feature characteristics. This chapter further expounds on the five results found in Chapter IV and includes a discussion of each.

The chapter beings by discussing the result that began from the first research question and was further confirmed by feature-to-feature comparisons from the second research question. This result showed that Practice problems and instructional Videos were more common, and more likely for teachers to have Access to than Interactive scenarios and the Adaptive feature. Because this result focused only on the four (out of six) features regarding students’ interactions with the programs, I next give a summary of trends and a short discussion for each of these four features individually. Next, I present a discussion for Results 2 and 3 which came from Grade Band comparisons for the second research question. Result 2 was that high school teachers are significantly less likely to have Access to five of the six features than elementary school teachers. Result 3 was simply that the trend in Result 2 did NOT hold for the Create/Revise feature. Because Result 3 focused only on the Create/Revise feature I also include an individual discussion
of this fifth feature. Lastly, Result 5 was that Teachers in Low SES elementary schools are significantly more likely to have Access to the Parent data access feature than teachers in Low SES elementary teachers. Because this result focused only on the Parent data access feature, this section also includes an individual discussion for this sixth feature. Therefore, by discussing Practice problems, instructional Videos, Interactive scenarios, and Adaptive individually with the discussion for Result 1; Create/Revise feature with the discussion for Result 3, and Parent data access with the discussion Result 5, by the end of the chapter, I discuss all five results as well as provide an individual discussion for each of the six features.

It is important to note that these data were collected in the spring of 2019, a full year before the COVID-19 pandemic. Research suggests that, as a result of the educational impacts felt during the COVID-19 pandemic, there was an increase in digital mathematics curriculum material use in general across the United States (Kaufman et al., 2021), but further research could explore the AIRS 2020 and the AIRS 2021 data sets to see how these trends in feature access changed through that time.

**Discussion for Result #1: Feature-to-Feature Comparisons**

The first research question concentrated on the prevalence of each of the six features of digital curriculum resources for mathematics instruction in teachers’ classrooms in 2019 based on the AIRS 2019. These results were reported in Table 3 and Figure 6 and provided observed percentages of Access to each feature, as well as predicted probabilities that a teacher would have access to each feature, prior to
considering characteristics. The second research question focused on the relationship between access to the six features of digital curriculum resources and school, teacher, and feature characteristics, whose analysis involved a multilevel logistic regression model with a three-way interaction between feature, grade band, and SES. Further feature-to-feature comparison analysis confirmed the results to the first research question.

Result 1 Part 1 was that Practice problems (81.9%, \( P = .910 \)) and instructional Videos (73.3%, \( P = .823 \)) were the most common and most likely features for teachers to have access to in programs they report using often, and Interactive scenarios (56.9%, \( P = .594 \)) and Adaptive (52.1%, \( P = .520 \)) features were the least common and least likely. 

In answer to the second research question, after taking into account school, teacher, and feature characteristics with the multilevel logistic regression model, as well as post-hoc feature-to-feature comparisons of the likelihood of feature access, Result 1 Part 2 was that Practice problems and instructional Videos were statistically significantly more likely than Interactive scenarios and Adaptive features in 22 of the 24 combinations of Grade Band and SES for these four features. This result simply confirmed the result from the first research question and therefore these results are discussed in tandem.

Four of the six features included in this study pertain to students’ interactions with the programs: Practice problems, instructional Videos, Interactive scenarios, and Adaptive (Choppin et al., 2014). The first three of these features (i.e., Practice problems, instructional Videos, and Interactive scenarios) focus on the learning experience for the student, while the other (i.e., Adaptive) involves how the program handles the sequence of these learning experiences. As the overall most common and least common features of
the six, these four features will be the main focus of this discussion and the other two features will be discussed later.

Practice problems and instructional Videos being more likely is not a surprising result because they are not only the easiest features to access for free, but they are also a common add-on feature in many digital curriculum resources. Although Practice problems and instructional Videos can be effective features for teaching and learning mathematics, they are consistent with traditional methods of mathematics teaching and have only been shown to be effective as supplementary material or under specific circumstances (de Araujo et al., 2017; Hattie & Timperley, 2007; Hillmayr et al., 2020; Hsin & Cigas, 2013; Kelly & Rutherford, 2017; Murphy et al., 2014; Van der Kleij et al., 2015; Wisniewski et al., 2020; Zengin, 2017). On the other hand, Interactive scenarios have been shown to improve mathematics learning more than other comparison treatments (Hillmayr et al., 2020; Moyer-Packenham & Westenskow, 2013).

This is important because Interactive scenarios have been shown to be more effective at teaching mathematics, but teachers are less likely to use programs that contain them. Additionally, although Adaptive features have not been shown to improve mathematics scores more than other treatments (Fang et al., 2019; Lovett et al., 2008), this feature has at least been shown to produce student learning pretest to posttest (Fang et al., 2019; Haelermans & Ghysels, 2017; Hagerty & Smith, 2005; Lovett et al., 2008; Pane et al., 2014), but it is the least likely feature for teachers to have access to. This is important because it is unfortunate that teachers are least likely to be using programs that contain the two features that research has shown to be more effective for supporting
students’ mathematics learning and achievement. Tosh et al. (2020) discusses the difficulty in determining what makes a quality digital material. This result sheds some light on this question of quality, because we know that teachers are less likely to be using the two features that research has shown are more effective, not just overall, but even within most Grade Band and SES subgroups.

The two p-values that were not significant were between Videos and Interactive for high school teachers. It is promising that high school teachers are not significantly more likely to be using programs with Videos than those with Interactive scenarios. It is important to note that this does not indicate a higher likelihood of Interactive scenarios, but rather, a lower likelihood of Videos. As will be discussed further in Result 2, this may be because high school teachers are more likely to be DIY teachers and, therefore, might be less inclined to use instructional Videos found in mathematics curriculum programs (Kaufman et al., 2020).

The next few sections will summarize trends for each of these four features individually that focus on students’ learning experiences: Practice problems, instructional Videos, Interactive scenarios, and Adaptive. Each section will also include any additional pertinent discussion of these trends.

**Practice Problems**

As discussed previously, Practice problems were, by far, the most common feature in classrooms (P = .910) and were statistically significantly more likely than Interactive scenarios and Adaptive in every grade band and SES combination. This means that all teachers have a high probability (P > .700) of using at least one program
that contains Practice problems. When people think of traditional mathematics, they think of Practice problems. Unfortunately, for many, Practice math problems and mathematics, in general, have come to be synonymous (Brownell, 1947). Although other learning experiences (such as Interactive scenarios) have been shown to produce more effective mathematics learning outcomes, Practice problems have been shown to be effective under certain circumstances (Haelermans & Ghysels, 2017; Hattie & Timperley, 2007; Hillmayr et al., 2020; Van der Kleij et al., 2015; Wisniewski et al., 2020). One such circumstance, as already discussed, is when the program is also Adaptive (Haelermans & Ghysels, 2017; Hagerty & Smith, 2005; Pane et al., 2014). Another such condition is when the program also includes explanatory feedback (Haelermans & Ghysels, 2017; Hattie & Timperley, 2007; Hillmayr et al., 2020; Van der Kleij et al., 2015; Wisniewski et al., 2020). This condition was not included in this study, but further investigation could be done to dig deeper into how these Practice problems are being used within each of the digital mathematics curriculum resources to better gauge the quality of these programs.

**Instructional Videos**

As discussed previously, instructional Videos were the second most likely feature in programs that teachers reported using in the AIRS 2019 dataset ($P = .823$). Instructional Videos show promise for mathematics learning, but only as a supplementary resource (de Araujo et al., 2017; Hsin & Cigas, 2013; Kelly & Rutherford, 2017; Murphy et al., 2014; Zengin, 2017). Tosh et al. (2020) and Kaufman et al. (2020) point out that most teachers use digital materials as a supplementary resource, but Low SES teachers are more likely to use a digital material as a “main” curriculum material. As will be
discussed in Result 4, Videos were more likely for Low SES middle school teachers than High SES middle school teachers. This is concerning because, if Low SES middle school teachers are using instructional Videos as their main instructional materials, this is the scenario that has not been shown to produce statistically significant learning gains in mathematics for students.

**Interactive Scenarios**

As discussed previously, Interactive scenarios were the second least likely feature for teachers to have access to ($P = .594$), and it was statistically significantly less likely than Practice problems in every grand band and SES combination. In addition to these trends, Result 2 will discuss how both middle school and high school teachers were statistically significantly less likely to use programs that contain Interactive scenarios than elementary teachers. Research has shown that Interactive scenarios not only support mathematics learning and achievement, but they have also been shown to be better than other methods in comparison treatments (Hillmayr et al., 2020; Moyer-Packenham & Westenskow, 2013). This is important because Interactive scenarios in digital mathematics curriculum materials could assist teachers with students’ learning, but teachers are less likely to have access to them, especially in middle school and high school. The reasons for this decrease in access to Interactive scenarios could simply be due to fewer quality options. Developers could address this need by creating more digital mathematics curriculum programs that include Interactive scenarios, especially for the middle school and high school content areas.
Adaptive

The probability of a teacher having access to the Adaptive feature was the lowest of the six features \((P = .520)\). The likelihood of this feature had similar trends as other features, except that it started lower and then dropped much more drastically from elementary to high school (see Result 2). This feature had the largest gap in likelihood between elementary and high school (from \(P \approx .75\) down to below \(P \approx .06\)). Although this Adaptive feature has not been shown to be more effective with regards to comparison groups (Fang et al., 2019; Lovett et al., 2008), it has still been shown to produce significant mathematics learning in prior studies (Haelermans & Ghysels, 2017; Hagerty & Smith, 2005; Pane et al., 2014). This is an important finding because this feature has the potential to produce higher learning gains in mathematics and only elementary teachers are likely to have access to it. One explanation for this result may be that fewer programs exist at the high school level in general, and there are much less programs that include the Adaptive feature. Digital curriculum developers should consider including this feature in their programs especially at higher grade bands.

Discussion for Result #2 and #3: Grade Band Comparisons and Create/Revise Feature

The second and third result also came in answer to the second research question, via the three-way interaction between feature, grade band, and SES within the multilevel logistic regression model. More specifically, these results came from post-hoc analysis of grade band comparisons of differences in probability of teachers’ access to feature. As
seen in Figure 11, probability values in Table F-1, and p values given in Table F-3, Result 2 is that high school teachers were statistically significantly less likely than elementary school teachers to have access to five of the six features (i.e., Practice problems, instructional Videos, Interactive scenarios, Adaptive, and Parent data access). Result 3 is that the create/revise feature is the only feature where there were no significant differences in likelihood between elementary and high school teachers.

First, it is important to note that this decline in probability of access for high school teachers does not necessarily mean that high school teachers are less likely to use digital mathematics curriculum, in general. However, this is not unreasonable. It is possible that high school teachers are less likely to use these five features simply because there may be fewer high-quality options for high school content. Although further research would need to be done to fully explore this, a quick look at the list of programs included on the survey (AIRS 2019) showed, anecdotally, that many of the programs do not extend into high school grade levels. This suggests that digital mathematics curriculum developers should create more programs that cover high school content, especially (based on Result 1) programs that include Interactive scenarios and/or Adaptive features.

Second, it is also possible that high school teachers are less likely to use programs that contain the Practice problems feature than elementary teachers because the problems found in high school content tend to be significantly longer, require several steps, and teachers desire to see students’ progression toward the correct answer. This is yet to be possible within digital mathematics curriculum. It is important to note that this finding
does not mean that high school teachers are more likely have access to the create/revise feature than Practice problems (they are actually about the same $P \approx .75$; see Table F-2), just that they are significantly less likely to have access to Practice problems than elementary teachers.

Third, a decline in the likelihood for Parent data access feature from elementary to high school is not surprising. This may just show a natural progression toward parents and teachers providing older children increased autonomy over their learning than younger children.

Fourth, perhaps Result 3 somewhat explains Result 2. Perhaps high school teachers’ higher likelihood for the create/revise feature somewhat explains their lower likelihood for the other five features. It stands to reason that if a program that contained the other five features (e.g., Practice problems), but not the ability to create and/or revise that content (e.g., the ability to add new custom Practice problems or make changes to those Practice problems), high school teachers might be less inclined to use those programs. This idea is consistent with findings from Kaufman et al. (2020) who reported that DIY (i.e., Do It Yourself) teachers are more likely to be high school teachers. Their research suggested that high school teachers might be more expert in their particular subject area, and, therefore, they feel more comfortable using self-created materials. Additionally, the ability to create and/or revise content is inherently less possible in the context of some features, like instructional Videos, Interactive scenarios, and Adaptive. First, it is quite impossible to revise the instructional Videos within digital curriculum. A teacher could create their own Videos and upload them to YouTube, but not directly to
Khan Academy. Second, perhaps the nature of Interactive scenarios makes it more difficult to include the create/revise feature. This finding suggests that developers could consider methods for teachers to create their own Interactive scenarios and/or revise some of the Interactive scenarios already present. Third, by nature, Adaptive features might make it more challenging to include the ability for teachers to create/revise content because, in order for teachers to create content, they would also need a way to connect that content with the existing content in order for the new content to be introduced in an Adaptive manner. However, this ability is not completely out of reach. Research has shown that giving teachers greater autonomy can lead to larger learning gains (Bullock, 2017), making the inclusion of this feature all the more vital. Result 2 and 3 suggest that digital mathematics curriculum developers should attempt to build-in ways for teachers to Create and/or Revise content within these programs.

**Discussion for Result #4: Socioeconomic Status Comparisons**

In answer to the second research question, the fourth result came from the three-way interaction between feature, grade band, and SES within the multilevel logistic regression model. More specifically, via post-hoc analysis of SES comparisons of differences in teachers’ probability to have access to each of six features. Result 4 was that there were no significant differences in SES for elementary or high school, but teachers in Low SES middle schools were statistically significantly more likely to have access to almost all six features than teachers in High SES middle schools (see Figure 12 and Table F-4). This was true for this dataset of teachers, with the possible exception of
Interactive scenarios, which approached significance, and may have reached significance if SES could have remained a four-level variable (see Figure 8). This means that Low SES middle school teachers in the AIRS 2019 dataset are significantly more likely to use programs containing these six features than teachers in High SES middle schools.

Additionally, there were no statistically significant differences between low and High SES for either elementary or high school teachers. This lack of difference is consistent with Kaufman et al. (2020) when they reported that these differences were significant for ELA (English Language Arts) but not for mathematics. These differences in SES were only seen once I included the interaction with grade band. It is unclear why this difference in SES would only be occurring for middle school teachers. These same RAND Corporation researchers suggest that the differences they found in SES for ELA might be because of a teachers’ desire to support their students, essentially because Low SES schools have higher learning needs (Kaufman et al., 2020; Tosh et al., 2020). One explanation for this result may be that teachers in Low SES schools are turning to digital mathematics curriculum resources to support their struggling students.

The challenges discussed in the previous paragraph could be addressed using increased teacher education (Remillard, 2016; Remillard & Kaye, 2002; Turner et al., 2012). With training, pre-service teachers and in-service teachers could learn to identify quality digital mathematics curriculum materials based on research and only use features in digital materials in such a manner that research has shown to be successful. For example, teachers could learn that instructional Videos have only been shown to be effective as a supplemental resource, and not as a main instructional material.
Discussion for Result #5: Parent Data Access

Like the other features, the results on Parent data access in the AIRS 2019 dataset declined from elementary to high school and revealed significant differences in SES for middle school teachers. However, Parent data access was the only feature that statistically significantly increased in probability for a higher grade band, specifically, Low SES middle school was higher than elementary. This means that Low SES middle school teachers were statistically significantly more likely to be using programs with Parent data access than elementary teachers. Prior research suggests that Parent data access can lead to greater mathematics achievement, but perhaps only for the younger grades (Baker, 2015; Dries, 2014; Haelermans & Ghysels, 2016; Lombardi & Dearing, 2020). This increase in likelihood of access to this feature could be happening for a number of reasons, and more research is needed in this area. This pattern may reflect a parents’ desire to be more involved in their middle schools students’ mathematics success. Perhaps this trend is simply a reflection of middle school teachers’ desire for parent involvement at such an important transition period for students’ mathematical success. Perhaps Parent data access is simply more prominent in digital materials that are comprehensive which may be more likely designed for Low SES teachers. Because parents have an important role to play in their children’s success, further research could explore the quality of and opportunities for parent involvement in digital materials (parental control vs parental support) (Silinskas & Kikas, 2019) because these differences could play a role in higher mathematics achievement.
Limitations

This section will outline some limitations of this study. The first two limitations come by nature of using existing data for the study. The third limitation is simply due to the complexity of the model.

The first limitation of this study is that because I used existing survey data (AIRS 2019) I could not control the questions that were included on the survey. Specifically, this study could not ask teachers whether they used the six features included in the study, which would have been preferable. Therefore, results could only report on whether teachers had access to the features in a digital mathematics curriculum program they reported using often. However, one advantage to this limitation was that it did not run the risk of teachers misunderstanding or having different conceptions of what is meant by each feature name. For example, “Adaptive” is defined completely differently by Choppin et al. (2014) and Hillymar et al. (2020). This would have been difficult to include in a survey like this and end up with accurate data.

The second limitation also comes because this study used existing data and I did not have influence over the data collection procedures. The study was planned as a three-level regression model, but because teachers were not sampled from the same school, all school-level variables had to be considered on the teacher level instead of on the school-level. This made it impossible to consider the nested nature of the data as originally planned. However, this model was still able to capture the nested nature of features within teachers. Conversely, if I had designed my own survey and conducted my own data collection, I would not have had such a large data sample size to work with, which
would have resulted in a different type of limitation.

The quasi-separation in data regarding the choice variable is another limitation of the study. The survey asked teachers whether specific programs were required, recommended, or neither. However, this question filtered the curriculum options to only include those that they had previously marked that they use often. Ideally, this question would have asked this question including the entire list of programs. However, the question included all curriculum, digital and nondigital, and therefore may have been too lengthy if it had included all curriculum options. These constraints are simply the nature of using existing data.

Lastly, the model in this study was too complex to include weights that would have made the sample a nationally representative sample. The original study included demographic weights for each teacher so that they could make conclusions about what is happening across the entire U.S. Unfortunately, at this time, there does not seem to be a method to include weights on a multilevel logistic regression model. There are methods for multilevel linear regression, and there are methods for single-level logistic regression, but not for multilevel logistic regression. Although the model could not be made into a nationally representative model, the findings are still informative, and statements can still be made about the sample without compromising the structural strengths of the model.

**Conclusions**

This study contributes to the extant literature on digital mathematics curriculum resources for teaching mathematics. First, the findings showed that traditional teaching
methods (in the form of Practice problems and instructional Videos) still dominate other methods (e.g., Interactive scenarios), even when teachers use digital curricula. Second, the results shed light on the differences between elementary and high school teachers’ curricula choices. Based on these findings, it appears that there is an important need for more high-quality digital programs for high school mathematics content, but these should not be developed at the expense of the ability to create and/or revise content. Third, this study contributed to and builds on the previous studies on the same dataset (AIRS 2019) by revealing that significant differences in SES levels do, in fact, exist regarding digital material use, but only for middle school teachers. The reasons for this are unclear, but future research could explore this further. These 2019 data results contribute much to the field, but additional examinations of AIRS 2020 and AIRS 2021 could provide interesting insights on the effect of mathematics instruction during the COVID-19 in terms of teachers’ access to the features in digital mathematics curriculum resources.
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Appendices
Appendix A. Institutional Review Board (IRB) Letter of Approval

Institutional Review Board
Exemption #4
Certificate of Exemption

From: Melanie Domenech Rodriguez, IRB Chair
To: Nicole Vouvalis, IRB Director
Date: January 26, 2022
Protocol #: 12437
Title: Relationships Between School, Teacher, and Feature Characteristics and Teachers’ Access to Features within Digital Curriculum Resources for Mathematics Instruction

The Institutional Review Board has determined that the above-referenced study is exempt from review under federal guidelines 45 CFR Part 46.104(a) category #4.

Research secondary research uses of identifiable private information or identifiable biospecimens, if at least one of the following criteria is met: (i) the identifiable private information or identifiable biospecimens are publicly available; (ii) information, which may include information about biospecimens, is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained directly or through identifiers linked to the subjects, the investigator does not have contact with the subjects, and the investigator will not re-identify subjects; or (iii) the research involves only information collection and analysis involving the investigator’s use of identifiable health information when that use is regulated under HIPAA*.

*All HIPAA requirements must be followed in obtaining the secondary data as set out in the approved protocol (including securing either HIPAA authorization or a Waiver of HIPAA authorization).

This exemption is valid for five years from the date of this correspondence, after which the study will be closed. If the research will extend beyond five years, it is your responsibility as the Principal investigator to notify the IRB before the study’s expiration date and submit a new application to continue the research. Research activities that continue beyond the expiration date without new certification of exempt status will be in violation of those federal guidelines which permit the exempt status.

If this project involves Non-USU personnel, they may not begin work on it (regardless of the approval status at USU) until a Reliance Agreement, External Research Agreement, or separate protocol review has been completed with the appropriate external entity. Many schools will not engage in a Reliance Agreement for Exempt protocols, so the research team must determine what the appropriate approval mechanism is for their Non-USU colleagues. As part of the IRB’s quality assurance procedures, this research may be randomly selected for audit during the five-year period of exemption. If so, you will receive a request for completion of an Audit Report form during the month of the anniversary date of this certification.

In all cases, it is your responsibility to notify the IRB prior to making any changes to the study by submitting an Amendment request. This will document whether or not the study still meets the requirements for exempt status under federal regulations.

Upon receipt of this memo, you may begin your research. If you have questions, please call the IRB office at (435) 797-1821 or email to irb@usu.edu.

The IRB wishes you success with your research.

435.797.1821 | 1450 Old Main Hill | Logan, UT 84322 | MAIN 155 | irb@usu.edu | FWA#00001308
Appendix B. Application to RAND Corporation for Dataset

Summary of the Research

RAND Corporation conducted a survey (AIRS 2019) which included a report of the specific digital curriculum materials teachers use at least once a week. They then reported percentages of teachers in different subgroups that use each specific curriculum material program. However, research has not explored “more-nuanced definitions and scenarios of digital material use” (Tosh et al., 2020, p. 10). To this end, this research seeks to break down the programs that teachers report using by feature to explore the relationship between teachers’ access to those features and contextual characteristics.

Researchers like Choppin et al. (2014) created a framework of features taken from comprehensive digital curriculum resources. This framework outlines the features surrounding student interactions, curriculum use and adaptation, and assessment systems. Based on Chopin et al’s (2014) framework of features, pertinence in the literature, and my interests, I have selected six specific features to be the focus of this study: instructional videos, interactive scenarios, practice problems, adaptive, create/revise content, and parent data access. These six features have the potential to greatly impact the effectiveness of digital curriculum and therefore positively impact student mathematics achievement. The promising effects of digital curriculum containing these features leads one to desire that all teachers have access them.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Sources</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1: Which features are most commonly found within digital curriculum resources selected by AIRS 2019 Survey Teacher Panel</td>
<td>Basic descriptive statistics. Percentages of teachers.</td>
<td></td>
</tr>
</tbody>
</table>
To answer the first research question, I will report simple descriptive statistics specifically using percentages, to report which features are most commonly used overall and which of the six chosen features are most commonly used among different subgroups of the population based on school characteristics (e.g., grade band, SES), teacher characteristics (e.g., experience), and feature characteristics (e.g., feature choice). To answer the second research question, I will conduct a 3-level generalized multilevel logistical regression (GLMM), with teachers’ access to each feature as the outcome variable and school characteristics (e.g., grade band and SES), teacher characteristics (e.g., experience) and feature characteristics (e.g., feature choice) as the multilevel independent variables to predict the probability that each feature type is in a program that is in use and whether these probabilities differ (via interactions) based on the characteristics. All analyses will be performed using R 4.0.2 (R Core Team, 2020). The lme4 1.1-23 package (Bates, 2015). The full reproducible code will be provided in the appendix.

### Justification for Restricted Data

<table>
<thead>
<tr>
<th>RQ2: What are the relationships between the most common features of digital math curriculum resources and a) school characteristics (e.g., grand band, SES), b) teacher characteristics (e.g., experience), and c) feature characteristics (e.g., feature choice)?</th>
<th>AIRS 2019 Survey Teacher Panel with programs broken down by containing features</th>
<th>Multilevel Logistic Regression DV=Access (0=No, 1=Yes) IV1=GradeBand IV2=SES IV3=Experience IV4=Feature Choice</th>
</tr>
</thead>
</table>

The reason I could not conduct the study as described using the public/deidentified data is because for my dependent variable I need to know the specific programs teachers report using so that report which features are in those programs that teachers are using. For example, teacher 1 uses: ALEKS yes, Assistments no, Brainpop no. The public data file does not provide this information, it appears to only provide counts for when no digital materials are used. Secondly, I require information from the CCD that is not included in the free dataset (e.g. school percent of Free or Reduced Lunch), but that RAND Corporation has already used (Tosh et al. 2020) and merged with the AIRS data.

Lastly, I require indicators for school, district, and state which were also not included in the public data file. Unlike NCES Code, these indicators (e.g., 1, 2, 3, ...) will prevent me from identifying which school/district/state the data came from but should
simply indicate that teacher 1 works at school 1 which is in district 1 which is in state 1. This information is absolutely vital because it will allow me to have the data nested in order to conduct a multilevel model but prevents the data from containing private sensitive information. If school identifiers do not provide the required nested structure, then district indicators would be ideal. However, if district does not provide the required nested structure, state indicators would be required. As primary researcher, I would like to determine for myself which indicators fit the data best as part of my dissertation learning experience, but I will take whatever information you will give based on your need to keep private information private. However, district OR state indicators are required.
Appendix C. American Instructional Resources Survey 2019 Excerpt

American Instructional Resources Survey (AIRS) 2019
American Teacher Panel

This survey was fielded on behalf of The Bill and Melinda Gates Foundation, the Charles and Lynn Schusterman Family Foundation and the Overdeck Family Foundation by the RAND American Educator Panels.

The American Educator Panels are comprised of the nationally representative American Teacher Panel (ATP) and the American School Leader Panel (ASLP). The panels consist of more than 25,000 K – 12 public school teachers (including oversamples in many states) and more than 5,000 principals who respond to online surveys several times per year.

If you would like additional information about the panels or would like to use the panels in your research, please contact us at 1-800-419-9566 or aep@rand.org, or visit the AEP website at www.rand.org/aep.

Please use the following citation if you use or adapt any items from this survey for your own use:


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**Your Teaching Assignment**

Questions in this section address your current teaching assignment for the 2018-19 school year.

---

**air_t_scr_001_m**

Respondents who indicated that they taught no grades between kindergarten and grade 12 (air_t_scr_001_m_00 = 0 AND air_t_scr_001_m_01 = 0 AND air_t_scr_001_m_02 = 0 AND air_t_scr_001_m_03 = 0 AND air_t_scr_001_m_04 = 0 AND air_t_scr_001_m_05 = 0 AND air_t_scr_001_m_06 = 0 AND air_t_scr_001_m_07 = 0 AND air_t_scr_001_m_08 = 0 AND air_t_scr_001_m_09 = 0 AND air_t_scr_001_m_10 = 0 AND air_t_scr_001_m_11 = 0 AND air_t_scr_001_m_12 = 0) were shown the following message (Thank you for your response. This survey is for current K-12th grade teachers only) and then terminated from the survey.

**This school year (2018-19), what grade(s) do you teach? Select all that apply**

00 Kindergarten  
01 Grade 1  
02 Grade 2  
03 Grade 3  
04 Grade 4  
05 Grade 5  
06 Grade 6  
07 Grade 7  
08 Grade 8  
09 Grade 9  
10 Grade 10  
11 Grade 11  
12 Grade 12  
13 Ungraded (including special education students aged 18-22)  
91 Other (please specify): __________________
RESPONDENTS WHO INDICATED THAT THEY DID NOT TEACH MATHEMATICS, ENGLISH LANGUAGE ARTS (ELA), OR SCIENCE WERE SHOWN THE FOLLOWING MESSAGE (Thank you for your response. This survey is for current ELA, mathematics or natural science teachers only. We look forward to your participation in future ATP surveys!) AND THEN TERMINATED FROM THE SURVEY.

RESPONDENTS WHO INDICATED THAT THEY TAUGHT ONLY ONE SUBJECT (OF MATHEMATICS, ELA, OR SCIENCE), WERE ASSIGNED THAT SUBJECT PATH FOR THE ENTIRE SURVEY. RESPONDENTS WHO INDICATED THAT THEY TAUGHT TWO OR THREE OF THE SUBJECTS WERE RANDOMLY ASSIGNED A SUBJECT PATH (subject_path = 1 (Math), subject_path = 2 (ELA), OR subject_path = 3 (Science)) BASED ON THE SUBJECTS THEY INDICATED THAT THEY TAUGHT.

Please indicate the main subject(s) you teach. If you teach more than one main subject (e.g., you are an elementary teacher of multiple subjects).

SELECT ALL THAT APPLY

01 Mathematics (including general mathematics, algebra, geometry, calculus, etc.)
02 English language arts (including English, language arts, reading, literature, writing, speech, etc.)
03 Natural science (including general science, biology, chemistry, physics, etc.)
04 Social science (including social studies, geography, history, government/civics, etc.)
05 Art and/or music
14 Health education
08 World languages
07 Computer science
09 Career or technical education
10 Special education
12 English as a Second Language (ESL) or English Language Development (ELD)
13 Physical education
91 Other (please specify): __________

RESPONDENTS WHO INDICATED EITHER THAT THEY DID NOT TEACH GRADES 6-12 (air_t_scr_001_m_06 THROUGH air_t_scr_001_m_12 = 0) OR THAT THEY DID NOT TEACH MATHEMATICS (air_t_scr_002_m_01 = 0) DID NOT SEE air_t_scr_004_m.

You indicated that you teach mathematics. Please indicate whether you teach algebra and/or geometry. If you teach an integrated mathematics course, check algebra and/or geometry if you address them in your integrated course.

01 Algebra I
02 Geometry
99 Not applicable - I do not teach Algebra or Geometry
Curriculum Materials: Mathematics

Questions in this section will ask you about the curricula (textbooks, lesson plans and units, and other instructional materials) and any digital materials you use to deliver instruction to your students.

IF RESPONDENT TAUGHT GRADES 6-8 AND EITHER OR BOTH OF GRADE K-5 AND GRADES 9-12, THEN THEY WERE ASSIGNED TO THE “MIDDLE SCHOOL LEVEL” PATH (grades = 2 (Middle)). IF RESPONDENT DID NOT TEACH GRADES 6-8 AND TAUGHT BOTH GRADES K-5 AND GRADES 9-12, THEN THEY WERE RANDOMLY ASSIGNED TO EITHER THE “ELEMENTARY SCHOOL LEVEL” PATH (grades = 1 (Elementary)) OR THE “HIGH SCHOOL LEVEL” PATH (grades = 3 (High)).

air_t_cmm_601_m

UNIVERSE: RESPONDENTS ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND THE ELEMENTARY SCHOOL LEVEL PATH (grades = 1 (Elementary)). SEE NOTE AT THE BEGINNING OF THE BLOCK.

Which of the following mathematics curricula do you use regularly (once a week or more) for your mathematics instruction this school year (2018-19)?

SELECT ALL THAT APPLY

**Elementary School (Grades K – 5)**

- **315** Bridges In Mathematics (Math Learning Center)
- **329** Common Core Coach (Triumph Learning or School Specialty, Inc)
- **332** Connecting Math Concepts (McGraw-Hill Education)
- **339** Creative Core Curriculum for Mathematics with STEM, Literacy and Art (TPS Publishing)
- **348** Edgenuity (Edgenuity, Inc)
- **353** EngageNY (NYSED)
- **356** enVision Math - 2012 (Pearson)
- **357** enVision Math 2.0 - 2016 (Pearson)
- **358** Eureka Math (Great Minds)
- **359** Everyday Math 3 (McGraw-Hill Education)
- **360** Everyday Math 4 (McGraw-Hill Education)

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114

371. Go Math (Houghton Mifflin Harcourt)
389. Investigations in Number, Data and Space 2nd Edition - 2012 (Pearson)
390. Investigations in Number, Data and Space 3rd Edition – 2017 (Pearson)
393. Japan Math (Japan Math Corp)
396. JUMP Math (JUMP Math)
399. LearnZillion Companion Curriculum
405. Match Fishtank (Match Education)
406. Math Expressions - 2013 (Houghton Mifflin Harcourt)
408. Math in Focus (Houghton Mifflin Harcourt)
414. Math Trailblazers (Kendall Hunt)
423. My Math - 2014 (McGraw-Hill Education)
440. Primary Math (Singapore)
447. Ready (Curriculum Associates)
450. Saxon Math (Houghton Mifflin Harcourt)
458. Singapore Math (Marshall Cavendish Education Pte Ltd)
467. Stepping Stones – 2014 (ORIGO Education)
468. Stepping Stones 2.0 – 2018 (ORIGO Education)
472. System of Courses (Pearson)
483. Wowzers (Wowzers, LLC)
484. Zearn (Zearn, Inc)
495. Curricula I create myself
496. Curricula my school or district created
491. Other curricula not listed (please specify): 
499. N/A - I do not use a particular curriculum regularly.
UNIVERSE: RESPONDENTS ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND THE MIDDLE SCHOOL LEVEL PATH (grades = 2 (Middle)). SEE NOTE AT THE BEGINNING OF THE BLOCK.

Which of the following mathematics curricula do you use regularly (once a week or more) for your mathematics instruction this school year (2018-19)?

SELECT ALL THAT APPLY

Middle School (Grade 6 – 8)

305 Agile Mind Middle School Mathematics (Agile Mind)
311 Big Ideas Math (Big Ideas Learning, LLC)
320 Carnegie Learning Math Series - 2011 (Carnegie Learning)
321 Carnegie Learning Math Solution - 2018 (Carnegie Learning)
329 Common Core Coach (Triumph Learning or School Specialty, Inc)
331 Connected Mathematics Project 3 (Pearson)
334 Core Connections (CPM Educational Programs)
339 Creative Core Curriculum for Mathematics with STEM, Literacy and Art (T²S Publishing)
344 Digits (Pearson)
345 Discovering Math (Singapore)
347 EdGems (EdGems, LLC)
348 Edgenuity (Edgenuity, Inc)
353 Engage NY (NYSED)
357 enVision Math 2.0 - 2016 (Pearson)
358 Eureka Math (Great Minds)
360 Everyday Math 4 (McGraw-Hill Education)
363 Flexbook Textbook (CK-12 Foundation)
365 FuelEd Summit Curriculum (Fuel Education, LLC)
369 Glencoe Math (McGraw-Hill Education)
371 Go Math (Houghton Mifflin Harcourt)
379 Holt McDougal Mathematics (Houghton Mifflin Harcourt)
384 Illustrative Math (Kendall Hunt or LearnZillion)
396 JUMP Math (JUMP Math)
405 Match Fishtank (Match Education)
408 Math in Focus (Houghton Mifflin Harcourt)
409 Math Innovations (Kendall Hunt)
410 Math Links (Center for Math and Teaching)
411 Math Techbook (Discovery Education)
429 Open Up Resources 6-8 Math or Illustrative Math (Open Up Resources)

Which of the following mathematics curricula do you use regularly (once a week or more) for your mathematics instruction this school year (2018-19)?

SELECT ALL THAT APPLY

High School (_grades 9 – 12)

304 Agile Mind (Agile Mind)
307 AMSCO Math: Algebra 1, Geometry, Algebra 2 (Perfection Learning)
310 Big Ideas Integrated (Big Ideas Learning, LLC)
312 Big Ideas Traditional (Big Ideas Learning, LLC)
319 Carnegie Integrated (Carnegie Learning)
322 Carnegie Traditional (Carnegie Learning)
323 CCSS Integrated Pathway (Walch Education)
324 CME Traditional (Pearson)
333 CORD: Learning in Context (CORD Communications)
336 Core-Plus Mathematics (McGraw-Hill Education)
337 CPM Integrated Math (CPM Education Program)
338 CPM Traditional Math (CPM Education Program)
346 Discovering Mathematics: Algebra, Geometry, Advanced Algebra (Kendall Hunt)
349 Edgenuity Integrated (Edgenuity, Inc)
350 Edgenuity Traditional (Edgenuity, Inc)
353 Engage NY (NYSED)
354 enVision A/G/A (Pearson)

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

Please indicate which digital materials your students and/or you use regularly (once a week or more) for mathematics instruction this school year (2018-19). If you do not use a resource, skip that row and move on to the next one.

SELECT ALL THAT APPLY IN EACH ROW

<table>
<thead>
<tr>
<th>My students use this once or week or more on their own during classroom instructional time</th>
<th>I use this once a week or more during whole-class instructional time or to plan my instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>703  ALEKS</td>
<td>1 □</td>
</tr>
<tr>
<td>704  Amplify</td>
<td>1 □</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>705</td>
<td>ASSISTments</td>
</tr>
<tr>
<td>706</td>
<td>BrainPOP</td>
</tr>
<tr>
<td>707</td>
<td>ck-12</td>
</tr>
<tr>
<td>709</td>
<td>Desmos</td>
</tr>
<tr>
<td>710</td>
<td>Dreambox</td>
</tr>
<tr>
<td>711</td>
<td>Edcite</td>
</tr>
<tr>
<td>714</td>
<td>Freckle</td>
</tr>
<tr>
<td>715</td>
<td>Greg Tang Math</td>
</tr>
<tr>
<td>716</td>
<td>Illuminations (NCTM)</td>
</tr>
<tr>
<td>717</td>
<td>i-Ready (Curriculum Associates)</td>
</tr>
<tr>
<td>718</td>
<td>ixl.com</td>
</tr>
<tr>
<td>719</td>
<td>Kahoot!</td>
</tr>
<tr>
<td>720</td>
<td>Khan Academy</td>
</tr>
<tr>
<td>721</td>
<td>LearnBop</td>
</tr>
<tr>
<td>722</td>
<td>LearnZillion</td>
</tr>
<tr>
<td>724</td>
<td>MobyMax</td>
</tr>
<tr>
<td>731</td>
<td>Prodigy</td>
</tr>
<tr>
<td>733</td>
<td>Quizlet</td>
</tr>
<tr>
<td>737</td>
<td>Redbird</td>
</tr>
<tr>
<td>738</td>
<td>Reflex</td>
</tr>
<tr>
<td>741</td>
<td>Splash Math</td>
</tr>
<tr>
<td>742</td>
<td>ST Math</td>
</tr>
<tr>
<td>743</td>
<td>Starfall</td>
</tr>
<tr>
<td>744</td>
<td>Study Island</td>
</tr>
<tr>
<td>745</td>
<td>Summit Learning (or Summit Basecamp)</td>
</tr>
<tr>
<td>748</td>
<td>XtraMath</td>
</tr>
<tr>
<td>749</td>
<td>YouTube</td>
</tr>
<tr>
<td>791</td>
<td>Other (please describe):</td>
</tr>
<tr>
<td>799</td>
<td>N/A – No digital materials are used regularly</td>
</tr>
</tbody>
</table>
UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

Which of the following additional digital materials do you reference or use regularly (once a week or more) to plan your mathematics instruction this school year (2018-19)?

SELECT ALL THAT APPLY

801 Achieve the Core
802 BetterLesson
803 Common Core State Standards Initiative (corestandards.org)
804 Common Sense Education
806 Edutopia
805 Edmodo
807 Kuta Software
809 Mathematics Assessment Project
808 Mathalicious
811 National Library of Virtual Manipulatives (NLVM)
815 OER Commons
816 Open Middle
818 Robert Kaplinsky
819 Scholastic Teacher
820 Share My Lesson
823 Teacher.org
822 Teacher Advisor with Watson
824 Teachers Pay Teachers
825 TeachingChannel
826 UnboundEd
828 Utah Middle School Math
821 State department of education website
827 Using a search engine (e.g. Google)
817 Resources obtained through a search on Pinterest
891 Other (please describe): ______________________
899 N/A – I do not use any other digital materials regularly
UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

To what extent are each of the following barriers to using digital materials?

<table>
<thead>
<tr>
<th></th>
<th>Not a barrier</th>
<th>A minor barrier</th>
<th>A major barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Internet access is not available and/or reliable at my school</td>
<td>1 ☐</td>
<td>2 ☐</td>
</tr>
<tr>
<td>02</td>
<td>Students do not have access to devices or reliable internet at home</td>
<td>1 ☐</td>
<td>2 ☐</td>
</tr>
<tr>
<td>03</td>
<td>My school does not have sufficient numbers of computers, tablets, or other electronic devices</td>
<td>1 ☐</td>
<td>2 ☐</td>
</tr>
<tr>
<td>04</td>
<td>My district or school does not support use of digital materials</td>
<td>1 ☐</td>
<td>2 ☐</td>
</tr>
<tr>
<td>05</td>
<td>I do not have enough knowledge about digital materials</td>
<td>1 ☐</td>
<td>2 ☐</td>
</tr>
<tr>
<td>06</td>
<td>Digital materials are expensive</td>
<td>1 ☐</td>
<td>2 ☐</td>
</tr>
<tr>
<td>07</td>
<td>Digital materials are not aligned with my state’s standards</td>
<td>1 ☐</td>
<td>2 ☐</td>
</tr>
<tr>
<td>08</td>
<td>Digital materials are inappropriate for my students</td>
<td>1 ☐</td>
<td>2 ☐</td>
</tr>
<tr>
<td>09</td>
<td>Digital materials are not engaging for my students</td>
<td>1 ☐</td>
<td>2 ☐</td>
</tr>
<tr>
<td>91</td>
<td>Other (please specify): ___________</td>
<td>1 ☐</td>
<td>2 ☐</td>
</tr>
</tbody>
</table>
UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

RESPONDENTS SEE ONLY THE MATERIALS THEY SELECTED IN (air_t_cmm_601_m OR air_t_cmm_602_m OR air_t_cmm_603_m) AND air_t_cmm_604_a.

Of the mathematics curricula and digital materials you indicated using regularly, please indicate how long you have been using those materials.

<table>
<thead>
<tr>
<th>MATERIALS SELECTED IN (air_t_cmm_601_m OR air_t_cmm_602_m OR air_t_cmm_603_m) AND air_t_cmm_604_a</th>
<th>Just this year</th>
<th>For the past 2-3 years</th>
<th>For the past 4-5 years</th>
<th>For more than 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

RESPONDENTS SEE ONLY THE MATERIALS THEY SELECTED IN (air_t_cmm_601_m OR air_t_cmm_602_m OR air_t_cmm_603_m) AND air_t_cmm_604_a.

Of the mathematics curricula and digital materials you indicated using regularly, please indicate which are provided by your district or school, either as a requirement or recommendation.

<table>
<thead>
<tr>
<th>MATERIALS SELECTED IN (air_t_cmm_601_m OR air_t_cmm_602_m OR air_t_cmm_603_m) AND air_t_cmm_604_a</th>
<th>Required by my district or school</th>
<th>Recommended by my district or school but not required</th>
<th>Neither required nor recommended by my district or school</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

RESPONDENTS SEE ONLY THE MATERIALS THEY SELECTED IN (air_t_cmm_601_m OR air_t_cmm_602_m OR air_t_cmm_603_m) AND air_t_cmm_604_a.

Of the mathematics curricula and digital materials you indicated using regularly, please indicate approximately what percent of mathematics instructional time you dedicate towards using them for a typical class of students each week?

<table>
<thead>
<tr>
<th>Materials Selected</th>
<th>10% or less</th>
<th>11%-24%</th>
<th>25%-49%</th>
<th>50%-74%</th>
<th>75-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(air_t_cmm_601_m OR air_t_cmm_602_m OR air_t_cmm_603_m) AND air_t_cmm_604_a</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

RESPONDENTS SEE ONLY THE MATERIALS THEY SELECTED IN (air_t_cmm_601_m OR air_t_cmm_602_m OR air_t_cmm_603_m) AND air_t_cmm_604_a.

Of the mathematics curricula and digital materials you indicated using regularly, please choose the ONE main material you use the most.

If there is not one main material you use most, or you use different main materials for different sets of students you teach, choose 2-3 main materials you use most.

This will be the “main material” you respond about for the remaining questions in this section.

<table>
<thead>
<tr>
<th>MATERIALS SELECTED IN (air_t_cmm_601_m OR air_t_cmm_602_m OR air_t_cmm_603_m) AND air_t_cmm_604_a. SELECTION WAS LIMITED TO 3 RESPONSES.</th>
<th>Not main materials</th>
<th>Main material used for the majority of my classroom lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 □</td>
<td>2 □</td>
</tr>
</tbody>
</table>
UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

Indicate your agreement with the following statements about your main mathematics materials.

<table>
<thead>
<tr>
<th>02</th>
<th>Help my students master my state’s mathematics standards</th>
<th>Not applicable for my students</th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
</tr>
</tbody>
</table>

| 03 | Cover content addressed by benchmark and districtwide assessments sufficiently | 99 □                           | 1 □               | 2 □               | 3 □           | 4 □           |

| 04 | Cover content addressed by my state-mandated assessment sufficiently | 99 □                           | 1 □               | 2 □               | 3 □           | 4 □           |

| 09 | Meet the needs of students with IEPs\(^{18}\) or 504 Plans\(^{19}\) | 99 □                           | 1 □               | 2 □               | 3 □           | 4 □           |

| 22 | Meet the needs of English Language Learners\(^{20}\) | 99 □                           | 1 □               | 2 □               | 3 □           | 4 □           |

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\(^{18}\) HOVER-OVER DEFINITION OF “IEPs”: Individualized Educational Plan (IEP) is a plan or program developed to ensure that a child who has a disability identified under the law receives specialized instruction and related services.

\(^{19}\) HOVER OVER DEFINITION OF “504 plans”: A 504 Plan is a plan developed to ensure that a child who has a disability identified under the law receives accommodations that will ensure their academic success and access to the learning environment.

\(^{20}\) HOVER-OVER DEFINITION OF “English Language Learners”: English Language Learners are students who come from non-English speaking homes and who are learning English.
<table>
<thead>
<tr>
<th></th>
<th>Not applicable for my students</th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>08</td>
<td>Provide me with a manageable number of topics to teach in a school year</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>14</td>
<td>Help me accelerate the learning of students who are performing below grade level</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>16</td>
<td>Provide suggestions for additional materials (e.g. pacing guides) or external resources for my lessons</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td></td>
<td>Not applicable for my students</td>
<td>Strongly disagree</td>
<td>Somewhat disagree</td>
<td>Somewhat agree</td>
<td>Strongly agree</td>
</tr>
<tr>
<td>18</td>
<td>Are culturally relevant</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>19</td>
<td>Are closely aligned with my district's goals and vision for good teaching</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>23</td>
<td>Provide digital instructional materials for use by all students</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>24</td>
<td>Provide digital instructional materials for use by students who are below grade level</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td></td>
<td>Not applicable for my students</td>
<td>Strongly disagree</td>
<td>Somewhat disagree</td>
<td>Somewhat agree</td>
<td>Strongly agree</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------</td>
<td>------------------</td>
<td>-------------------</td>
<td>----------------</td>
<td>---------------</td>
</tr>
<tr>
<td>25</td>
<td>Provide digital instructional materials for use by English Language Learners(^{21})</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>20</td>
<td>Provide texts and topics that are linguistically appropriate for English Language Learners(^{22})</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>27</td>
<td>Are engaging for students</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>29</td>
<td>Are very user-friendly and easy for me to implement</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
</tbody>
</table>

\(^{21}\) HOVER-OVER DEFINITION OF "English Language Learners": English Language Learners are students who come from non-English speaking homes and who are learning English

\(^{22}\) HOVER-OVER DEFINITION OF "English Language Learners": English Language Learners are students who come from non-English speaking homes and who are learning English
UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

My main mathematics materials are ...

<table>
<thead>
<tr>
<th></th>
<th>Not applicable for my students</th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>01 Too challenging for most students</strong></td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
</tr>
<tr>
<td><strong>02 At the right level for most students</strong></td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
</tr>
<tr>
<td><strong>03 Not challenging enough for most students</strong></td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
</tr>
<tr>
<td><strong>04 Provide differentiated (i.e., scaffolded) materials to meet the needs of different students</strong></td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
</tr>
</tbody>
</table>
Intervention Materials

The following questions pertain to intervention materials that you use in your classroom to support students below grade level.

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

Which of the following mathematics intervention materials do you use to support students below grade level?

SELECT ALL THAT APPLY

851 3-Tier Math Model Intervention (Meadows Center)
852 Assessment and Learning in Knowledge Spaces (ALEKS) (McGraw-Hill Education)
853 Do The Math (Scholastic/Houghton Mifflin Harcourt)
854 Do The Math Now! (Scholastic/Houghton Mifflin Harcourt)
855 enVision MATH: Diagnosis and Intervention System (Pearson)
856 eSTAR (Round Rock ISD)
857 focusMATH (Pearson)
858 Math Expressions: Response to Intervention (Houghton Mifflin Harcourt)
859 Math Navigator (Pearson)
860 MathXL for School (Pearson)
861 MSTAR (The University of Texas at Austin/The Meadows Center for Preventing Educational Risk)
862 MyPath (Edgenuity, Inc)
863 On Ramp to Algebra (Pearson)
864 Response to Intervention (RTI) Everyday Intervention (Nasco)
865 Study Island (Edmentum)
866 SuccessMaker (Pearson)
867 Total Motivation Math (Mentoring Minds)
991 Other (please specify): 
999 N/A – I do not use intervention materials
**air_t_cmm_620_g**

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

RESPONDENTS SEE ONLY THE MATERIALS THEY SELECTED IN air_t_cmm_613_m.

Of the mathematics intervention materials you indicated using, please indicate how frequently your students use those materials.

<table>
<thead>
<tr>
<th>MATERIALS SELECTED IN air_t_cmm_613_g</th>
<th>1 time per month</th>
<th>2-3 times per month</th>
<th>1-2 times per week</th>
<th>3-5 times per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 boxes</td>
<td>3 boxes</td>
<td>4 boxes</td>
<td>5 boxes</td>
<td></td>
</tr>
</tbody>
</table>

**air_t_cmm_614_g**

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

RESPONDENTS SEE ONLY THE MATERIALS THEY SELECTED IN air_t_cmm_613_m.

For each of the intervention materials you indicated using, how would you rate the extent to which they prepare students to access your main mathematics materials?

<table>
<thead>
<tr>
<th>MATERIALS SELECTED FOR air_t_cmm_613_g</th>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Fully</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 box</td>
<td>2 boxes</td>
<td>3 boxes</td>
<td>4 boxes</td>
<td></td>
</tr>
</tbody>
</table>
Modifying and Supplementing Materials

The following questions ask about when you make modifications or supplement your main materials. When we refer to “supplement” in this section, we are referring to use of any materials (i.e., curricula, digital materials, etc.) in addition to what you indicated were your main materials.

Please complete the following sentence. 23
I typically use lesson plans from my main mathematics materials...

99 N/A – My main materials do not include lesson plans or I typically create my own lesson plans.
1 ... with no or few modifications.
2 ... with modifications to less than half of a lesson plan.
3 ... with modifications to more than half of a lesson plan.

Please indicate the frequency with which you make the following types of modifications to your main mathematics materials.

I skip activities, modify activities, or supplement my main mathematics materials to...

<table>
<thead>
<tr>
<th>Make them more culturally relevant for my students</th>
<th>N/A – I do not make this type of modification</th>
<th>Less than once a week</th>
<th>Once a week</th>
<th>2-3 times a week</th>
<th>For nearly every lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>N/A – I do not make this type of modification</th>
<th>Less than once a week</th>
<th>Once a week</th>
<th>2-3 times a week</th>
<th>For nearly every lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>Make them more challenging for my students</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>03</td>
<td>Make them less challenging for my students</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>04</td>
<td>Make them more relevant to my students' future education and careers</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>05</td>
<td>Make them more appropriate for my students with IEPs[^24] or 504 Plans[^25]</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>06</td>
<td>Make them more appropriate for English Language Learners[^26]</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>07</td>
<td>Make them more appropriate for students who are below grade level</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
</tbody>
</table>

[^24]: HOVER-OVER DEFINITION OF “IEPs”: Individualized Educational Plan (IEP) is a plan or program developed to ensure that a child who has a disability identified under the law receives specialized instruction and related services.

[^25]: HOVER-OVER DEFINITION OF “504 plans”: A 504 Plan is a plan developed to ensure that a child who has a disability identified under the law receives accommodations that will ensure their academic success and access to the learning environment.

[^26]: HOVER-OVER DEFINITION OF “English Language Learners”: English Language Learners are students who come from non-English speaking homes and who are learning English.
<table>
<thead>
<tr>
<th></th>
<th>N/A – I do not make this type of modification</th>
<th>Less than once a week</th>
<th>Once a week</th>
<th>2-3 times a week</th>
<th>For nearly every lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td>08</td>
<td>Reduce the time they will take (e.g., fit them into the lesson or into a unit)</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>09</td>
<td>Better address my students' learning needs, based on assessment results</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>10</td>
<td>Better address state standards</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>11</td>
<td>Better address the content in my subject area</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>12</td>
<td>Scale them for a larger class size</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>91</td>
<td>Other (please describe):</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
</tbody>
</table>
**Principal Support and Instruction**

The following questions pertain to your overall experience teaching mathematics (e.g., priorities, resources, support, etc.) in your school.

**UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).**

Indicate your agreement with the following statements.

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>My principal encourages me to use existing mathematics curricula as the basis for my lessons.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>My principal encourages me to plan lessons from scratch instead of using existing mathematics curricula.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>03</td>
<td>My principal provides me with feedback on how well I use mathematics curricula.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>N/A</th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>My principal knows which curricula are and are not aligned with my state's standards.</td>
<td>99</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>05</td>
<td>My teacher evaluations take into account my use of the required mathematics curricula.</td>
<td>99</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>N/A</td>
<td>Strongly disagree</td>
<td>Somewhat disagree</td>
<td>Somewhat agree</td>
</tr>
<tr>
<td>----------------</td>
<td>-----</td>
<td>-------------------</td>
<td>------------------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>06</strong> My teacher <em>observations</em> take into account my use of the required mathematics curricula.</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
</tbody>
</table>

In this school year (2018-19), what proportion of your students typically engage in each of the following activities at least once a week for the mathematics classes you teach?  

<table>
<thead>
<tr>
<th></th>
<th>No students</th>
<th>A few of my students</th>
<th>Less than half of my students</th>
<th>More than half of my students</th>
<th>All or nearly all my students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>01</strong> Spend at least half of instructional time on grade-level mathematics topics addressed by the state mathematics standards for my grade level</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td><strong>02</strong> Relate new mathematics content to other mathematics content within and across grade levels</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th></th>
<th>No students</th>
<th>A few of my students</th>
<th>Less than half of my students</th>
<th>More than half of my students</th>
<th>All or nearly all my students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>03</strong> Pursue conceptual understanding, procedural skill and fluency, and application with equal intensity</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td><strong>04</strong> Explain their thinking and build on other students’ thinking</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td><strong>05</strong> Make sense of problems that do not include clear procedures for solving and persevere in solving them</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td><strong>06</strong> Use repeated practice to improve their computational skills</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td><strong>07</strong> Apply mathematics to solve problems in real-world contexts</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td></td>
<td>No students</td>
<td>A few of my students</td>
<td>Less than half of my students</td>
<td>More than half of my students</td>
<td>All or nearly all my students</td>
</tr>
<tr>
<td>---</td>
<td>-------------</td>
<td>----------------------</td>
<td>-------------------------------</td>
<td>-------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>08</td>
<td>Look for and make use of structure (e.g., patterns in numbers, shapes or algorithms)</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
</tr>
<tr>
<td>09</td>
<td>Choose and use appropriate tools when solving a problem</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
</tr>
</tbody>
</table>

**UNIVERSE:** RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

Do you receive feedback from observations of mathematics instruction that helps you improve your instructional practice?

99 N/A – I don’t receive feedback from observations of my mathematics instruction
1 No
2 Yes
Professional Learning

Questions in this section will ask you about your professional learning activities. By professional learning, we mean the supports you receive to improve your teaching practice and knowledge (e.g., coaching and feedback, workshops, collaborative learning with other teachers).

**THE SUBJECT WAS PREFILLED BASED ON THE ASSIGNED SUBJECT PATH.**

**UNIVERSE: ALL RESPONDENTS**

This school year (2018-19), how often have you participated in the following types of [ELA/mathematics/science] professional learning activities?

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>1-3 times per year</th>
<th>4-6 times per year</th>
<th>1-3 times per month</th>
<th>Weekly or more often</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>01</strong> Workshops or trainings focused on [SUBJECT AREA] teaching and learning</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>02</strong> Workshops or trainings focused on use of my main [SUBJECT AREA] materials</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>03</strong> General (not subject-specific) workshops or trainings</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>04</strong> Coaching focused on my [SUBJECT AREA] teaching</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Never</td>
<td>1-3 times per year</td>
<td>4-6 times per year</td>
<td>1-3 times per month</td>
<td>Weekly or more often</td>
</tr>
<tr>
<td>---</td>
<td>-------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>05</td>
<td>Coaching focused on use of my main [SUBJECT AREA] materials</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
</tr>
<tr>
<td>06</td>
<td>Collaborative learning with other teachers (e.g., Professional Learning Communities) focused on [SUBJECT AREA] teaching and learning</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
</tr>
<tr>
<td>07</td>
<td>Collaborative learning with other teachers (e.g., Professional Learning Communities) focused on use of my main [SUBJECT AREA] instructional materials</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
</tr>
<tr>
<td>08</td>
<td>Online learning I access on my own</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
</tr>
<tr>
<td>91</td>
<td>Other in-person trainings that I access on my own (please specify): ___________</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
</tr>
</tbody>
</table>
UNIVERSE: ALL RESPONDENTS

Please indicate whether the following professional learning activities in which you have participated were provided by district/school staff or an external vendor from outside of your district.

<table>
<thead>
<tr>
<th>OPTIONS FROM air_t_prl_651_g 01-05 WHERE RESPONDENTS SELECT GREATER THAN 1 (NEVER)</th>
<th>Provided by district/school staff</th>
<th>Provided by an external vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

UNIVERSE: ALL RESPONDENTS

This school year (2018-19), to what extent have the professional learning activities in which you participated helped you to improve your use of your main [ELA/mathematics/science] materials?

<table>
<thead>
<tr>
<th>OPTIONS FROM air_t_prl_651_g 01-91 WHERE RESPONDENTS SELECT GREATER THAN 1 (NEVER)</th>
<th>Not at all</th>
<th>To a small extent</th>
<th>To a moderate extent</th>
<th>To a great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
UNIVERSE: ALL RESPONDENTS
ROWS WITHIN TABLES WERE RANDOMIZED. THE ORDER OF THE TABLES WAS RANDOMIZED.

Indicate your agreement with the following statements about your professional learning activities during this school year (2018-19).

The professional learning activities in which I’ve participated this school year (2018-19) helped me to:

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Use my instructional materials more effectively to meet student needs</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>02</td>
<td>Engage in instructional practices that more effectively meet student needs</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>03</td>
<td>Address my own mindsets and biases about student achievement</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>N/A</th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>Address the needs of students below grade level</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>05</td>
<td>Use data effectively to modify and improve instruction</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>06</td>
<td>Better understand the subject area(s) I teach</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
</tbody>
</table>
Since the end of last school year (2017–18), how many hours did you spend in professional learning activities related to the following topics in [SUBJECT AREA]? It’s okay to estimate if you do not know the exact amount of time.  

<table>
<thead>
<tr>
<th></th>
<th>0 hours</th>
<th>1-5 hours</th>
<th>6-10 hours</th>
<th>11-20 hours</th>
<th>21-30 hours</th>
<th>31-40 hours</th>
<th>41-60 hours</th>
<th>61-80 hours</th>
<th>More than 80 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Understanding my state standards in [SUBJECT AREA]</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
<td>6 □</td>
<td>7 □</td>
<td>8 □</td>
</tr>
<tr>
<td>02</td>
<td>Developing my knowledge of content in [SUBJECT AREA]</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
<td>6 □</td>
<td>7 □</td>
<td>8 □</td>
</tr>
<tr>
<td>03</td>
<td>Observing other teachers’ lessons (in person or on video) that model instruction aligned to the standards in [SUBJECT AREA]</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
<td>6 □</td>
<td>7 □</td>
<td>8 □</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th></th>
<th>0 hours</th>
<th>1-5 hours</th>
<th>6-10 hours</th>
<th>11-20 hours</th>
<th>21-30 hours</th>
<th>31-40 hours</th>
<th>41-60 hours</th>
<th>61-80 hours</th>
<th>More than 80 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>04 Receiving feedback from observations on my [SUBJECT AREA] lessons</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
<td>5 ☐</td>
<td>6 ☐</td>
<td>7 ☐</td>
<td>8 ☐</td>
<td>9 ☐</td>
</tr>
<tr>
<td>05 Learning how to implement my main instructional materials</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
<td>5 ☐</td>
<td>6 ☐</td>
<td>7 ☐</td>
<td>8 ☐</td>
<td>9 ☐</td>
</tr>
<tr>
<td>06 Modifying my main instructional materials so that they will better align to the standards in [SUBJECT AREA]</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
<td>5 ☐</td>
<td>6 ☐</td>
<td>7 ☐</td>
<td>8 ☐</td>
<td>9 ☐</td>
</tr>
<tr>
<td>07 Modifying my main instructional materials to meet the needs of students below grade level</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
<td>5 ☐</td>
<td>6 ☐</td>
<td>7 ☐</td>
<td>8 ☐</td>
<td>9 ☐</td>
</tr>
<tr>
<td>08 Modifying my main instructional materials to provide culturally relevant instruction</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
<td>5 ☐</td>
<td>6 ☐</td>
<td>7 ☐</td>
<td>8 ☐</td>
<td>9 ☐</td>
</tr>
<tr>
<td></td>
<td>0 hours</td>
<td>1-5 hours</td>
<td>6-10 hours</td>
<td>11-20 hours</td>
<td>21-30 hours</td>
<td>31-40 hours</td>
<td>41-60 hours</td>
<td>61-80 hours</td>
<td>More than 80 hours</td>
</tr>
<tr>
<td>---</td>
<td>---------</td>
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<td>------------</td>
<td>-------------</td>
<td>-------------</td>
<td>-------------</td>
<td>-------------</td>
<td>-------------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>09</strong></td>
<td>Analyzing student work to determine whether it met the expectations of the standards in [SUBJECT AREA]</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
<td>6 □</td>
<td>7 □</td>
<td>8 □</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>Learning instructional strategies that support my students in meeting the demand of the [SUBJECT AREA] standards</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
<td>6 □</td>
<td>7 □</td>
<td>8 □</td>
</tr>
</tbody>
</table>
Teacher Preparation Programs

Questions in this section will ask you about your teacher preparation experiences.

**air_t_tpp_305_s_00**

**UNIVERSE: ALL RESPONDENTS**

**How long ago did you complete your formal teacher preparation program?**

99 N/A – I did not complete a formal teacher preparation program
1 In the last five years (2014 or later)
2 More than five years ago

**air_t_tpp_306_s_00**

**UNIVERSE: RESPONDENTS WHO COMPLETED A FORMAL PREPARATION PROGRAM IN THE LAST FIVE YEARS (air_t_tpp_305_s_00 = 1).**

**What kind of preparation did you primarily receive before becoming a classroom teacher?**

1 I went through a university-run teacher preparation program.
2 I went through a district- or CMO- run teacher preparation program.
3 I went through a teacher preparation program that was run by an entity besides a university, district, or CMO.
91 Other (please specify): ____________

**air_t_tpp_307_s_00**

**UNIVERSE: RESPONDENTS WHO COMPLETED A FORMAL PREPARATION PROGRAM IN THE LAST FIVE YEARS (air_t_tpp_305_s_00 = 1).**

**Please select the type of program through which you were prepared to teach.**

1 Traditional teacher preparation program
2 Alternative certification program
98 I don’t know
UNIVERSE: RESPONDENTS WHO COMPLETED A FORMAL PREPARATION PROGRAM IN THE LAST FIVE YEARS (air_t_tpp_305_s_00 = 1).

Which of the following did your program emphasize more (pick one):

1. My program emphasized how to develop my own lessons and unit plans from scratch.
2. My program emphasized curriculum literacy, focusing on how to skillfully use and modify curricula provided to me.
3. My program emphasized both of these approaches equally.
4. My program emphasized neither of these approaches.

UNIVERSE: RESPONDENTS WHO COMPLETED A FORMAL PREPARATION PROGRAM IN THE LAST FIVE YEARS (air_t_tpp_305_s_00 = 1) WHICH EMPHASIZED CURRICULUM LITERACY (air_t_tpp_308_s_00 = 2 OR air_t_tpp_308_s_00 = 3).

You indicated that your program emphasized curriculum literacy. Did courses in your program provide you with practice in using or modifying specific curricular materials?

0. No
1. Yes

UNIVERSE: RESPONDENTS WHO COMPLETED A FORMAL PREPARATION PROGRAM IN THE LAST FIVE YEARS (air_t_tpp_305_s_00 = 1).

ROWS WITHIN TABLES WERE RANDOMIZED. THE ORDER OF THE TABLES WAS RANDOMIZED.

Indicate your agreement with the following statements about your teaching preparation program (including practicum/internship).

<table>
<thead>
<tr>
<th>Statement</th>
<th>I don’t remember or N/A</th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 My program prepared me to identify the strengths and weaknesses of curricular materials.</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
</tr>
<tr>
<td></td>
<td>I don’t remember or N/A</td>
<td>Strongly disagree</td>
<td>Somewhat disagree</td>
<td>Somewhat agree</td>
<td>Strongly agree</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------</td>
<td>-------------------</td>
<td>------------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>02</td>
<td>My program provided adequate support on how to skillfully use and modify curricular materials to meet student needs.</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>03</td>
<td>The amount of clinical training I received (i.e., teaching internship or residency) was adequate.</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>04</td>
<td>The mentor teacher who supported me during my clinical training (i.e., teaching internship or residency) was effective in helping me improve.</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>05</td>
<td>My program offered content-specific coaching for the subject(s) I teach.</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>06</td>
<td>My program helped me build content-specific knowledge for the subject(s) I teach.</td>
<td>99 □</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
</tbody>
</table>
Standards-Aligned Instructional Content and Approaches

Questions in this section ask questions about which approaches are most aligned with your state’s standards. Please respond to these questions taking into account what you know about your state standards. If you do not know which items are most aligned with your state standards, please feel free to indicate “I don’t know.”

PN: ONLY DISPLAY TO ELA AND MATHEMATICS PATHS

[BLOCK 1: ENGLISH LANGUAGE ARTS]

air_t_tkp_676_m

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE ELA SUBJECT PATH (subject_path = 2 (ELA)).

Which of the following approaches for selecting reading texts aligns with your state’s English language arts & literacy standards? ⁴⁰

SELECT ALL THAT APPLY

01 Select abridged or adapted versions of complex texts for students below grade level
02 Select grade-level texts that all students read as a class
03 Select texts for individual students based on their reading level
04 Select texts for a class based on qualitative factors like knowledge demands, as well as quantitative factors like word and sentence length
91 Other (please specify): ______________________
98 I don’t know

---

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE ELA SUBJECT PATH (subject_path = 2 (ELA)) AND THE ELEMENTARY SCHOOL LEVEL PATH (grades = 1 (Elementary)).

The following are pairs of questions a teacher might ask about a nonfiction text excerpt, “Lost Penguin Back in his Natural Habitat,” about a penguin native to Antarctica who was found on a beach in New Zealand.41

For each pair, please indicate which teacher question is more aligned with the focus of your state standards for English Language Arts and Literacy. Please disregard the grade-level of the text when responding.

<table>
<thead>
<tr>
<th>Pair</th>
<th>Question A</th>
<th>Question B</th>
<th>I don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>1 What would you do if you discovered a lost animal?</td>
<td>2 What detail from the article best explains how people should approach a penguin?</td>
<td>3 □</td>
</tr>
<tr>
<td>02</td>
<td>1 What is the author’s tone in this article? Find some evidence from the text to justify your response.</td>
<td>2 What lesson did you learn from reading this article?</td>
<td>3 □</td>
</tr>
<tr>
<td>03</td>
<td>1 Can you think of any other stories where animals have gotten lost?</td>
<td>2 What is the main idea of this article? Find key details to support your claims.</td>
<td>3 □</td>
</tr>
<tr>
<td>04</td>
<td>1 What phrases or sentences in the text help the reader understand what the word “habitat” means?</td>
<td>2 Have you ever felt like you were out of your natural habitat?</td>
<td>3 □</td>
</tr>
</tbody>
</table>

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE ELA SUBJECT PATH (subject_path = 2 (ELA)) AND THE MIDDLE SCHOOL LEVEL PATH (grades = 2 (Middle)) OR THE HIGH SCHOOL LEVEL PATH (grades = 3 (High)).

The following are pairs of questions a teacher might ask about a nonfiction text excerpt from “The Omnivore’s Dilemma.”

For each pair, please indicate which teacher question is more aligned with the focus of your state standards for *English Language Arts and Literacy*. Please disregard the grade-level of the text when responding.

<table>
<thead>
<tr>
<th>Pair</th>
<th>Question A</th>
<th>Question B</th>
<th>I don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>1 Do you think that corn has pushed out other foods in our food chain?</td>
<td>2 In which paragraph does the author provide information that helps explain why farmers embraced the use of chemical fertilizer?</td>
<td>3 □</td>
</tr>
<tr>
<td>02</td>
<td>1 What is the author’s tone in this article? Find some evidence from the text to justify your response.</td>
<td>2 What lesson did you learn from reading this article?</td>
<td>3 □</td>
</tr>
<tr>
<td>03</td>
<td>1 Can you think of ways that businesses have determined what we eat?</td>
<td>2 What is the main idea of this article? Find key details from the text to support your claims.</td>
<td>3 □</td>
</tr>
<tr>
<td>04</td>
<td>1 In paragraph 4, which phrase best helps the reader understand what the word surplus means?</td>
<td>2 Can you think of some examples of where corn is found in everyday products?</td>
<td>3 □</td>
</tr>
</tbody>
</table>

---

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE ELA SUBJECT PATH (subject_path = 2 (ELA)).

Which of the following types of writing assignments align with your state’s English language arts and literacy standards?

SELECT ALL THAT APPLY

01 Write an opinion piece or argument on a topic or text, supporting a point of view with reasons and sufficient evidence
02 Write an informative/explanatory text that develops a topic with relevant details and other information
03 Write a creative fictional scene that depicts characters and/or experiences in vivid detail
04 Write a narrative to develop real or imagined experiences with descriptive details and clear event sequences
05 Write a play about real or imagined characters that conveys a larger idea about the world
98 I don’t know

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE ELA SUBJECT PATH (subject_path = 2 (ELA)).

To what extent do your state standards focus on the following types of vocabulary instructions? 43

<table>
<thead>
<tr>
<th>01 Teach words related to a specific content area or text being covered in class (e.g., teaching “magma” when reading a text about volcanoes)</th>
<th>Not at all</th>
<th>To a slight extent</th>
<th>To a moderate extent</th>
<th>To a great extent</th>
<th>I don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
<td>4 ☐</td>
<td>98 ☐</td>
</tr>
</tbody>
</table>

---


---
<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>To a slight extent</th>
<th>To a moderate extent</th>
<th>To a great extent</th>
<th>I don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>Teach words students are likely to encounter when reading in a variety of content areas that do not have content-specialized definitions (e.g., “establish” and “verify”)</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
</tr>
<tr>
<td>91</td>
<td>Other (please describe):</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
</tr>
</tbody>
</table>

**[BLOCK 2: MATHEMATICS]**

`air_t_tkp_681_m`

**UNIVERSE:** RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT KINDERGARTEN (air_t_scr_001_m_00 = 1).

Which of the following major topics are emphasized in the Kindergarten mathematics class(es) you teach, according to your state standards for mathematics?\(^{44}\)

**SELECT ALL THAT APPLY**

- 01 Compare numbers
- 02 Tell and write time from analog and digital clocks to the nearest five minutes using a.m. and p.m.
- 03 Develop understanding of fractions as numbers
- 04 Understand meaning of addition and subtraction
- 98 I don't know

---

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT GRADE 01 (air_t_scr_001_m_01 = 1).

Which of the following major topics are emphasized in the 1st grade mathematics class(es) you teach, according to your state standards for mathematics? 44

SELECT ALL THAT APPLY

01 Add and subtract within 20
02 Measure lengths indirectly and by iterating length units
03 Extend understanding of fraction equivalence and ordering
04 Identify arithmetic patterns (including patterns in the addition or multiplication tables) and explain them using properties of operations
98 I don’t know

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT GRADE 02 (air_t_scr_001_m_02 = 1).

Which of the following major topics are emphasized in the 2nd grade mathematics class(es) you teach, according to your state standards for mathematics? 45

SELECT ALL THAT APPLY

01 Identify line of symmetry in two dimensional figures
02 Understand place value
03 Apply and extend previous understandings of multiplication and division to multiply and divide fractions
04 Represent and solve problems involving addition
98 I don’t know

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT GRADE 03 (air_t_scr_001_m_03 = 1).

Which of the following major topics are emphasized in the 3rd grade mathematics class(es) you teach, according to your state standards for mathematics?  

SELECT ALL THAT APPLY

01 Multiply and divide within 100
02 Display numerical data in plots on a number line, including dot plots, histograms, and box plots
03 Develop understanding of fractions as numbers
04 Understand meaning of addition and subtraction
98 I don’t know

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT GRADE 04 (air_t_scr_001_m_04 = 1).

Which of the following major topics are emphasized in the 4th grade mathematics class(es) you teach, according to your state standards for mathematics?  

SELECT ALL THAT APPLY

01 Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates
02 Generalize place value understanding for multi-digit whole numbers
03 Extend understanding of fraction equivalence and ordering
04 Understand ratio concepts and use ratio reasoning to solve problems
98 I don’t know
UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT GRADE 05 (air_t_scr_001_m_05 = 1).

Which of the following major topics are emphasized in the 5th grade mathematics class(es) you teach, according to your state standards for mathematics? 46

SELECT ALL THAT APPLY

01 Apply and extend previous understandings of multiplication and division to multiply and divide fractions
02 Understand the place value system
03 Find probabilities of compound events using organized lists, tables, tree diagrams, and simulation
04 Recognize and draw shapes having specific attributes, such as a given number of angles or a given number of equal faces
98 I don’t know

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT GRADE 06 (air_t_scr_001_m_06 = 1).

Which of the following major topics are emphasized in the 6th grade mathematics class(es) you teach, according to your state standards for mathematics? 46

SELECT ALL THAT APPLY

01 Understand ratio concepts and use ratio reasoning to solve problems
02 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points
03 Perform operations with numbers expressed in scientific notation
04 Apply and extend previous understandings of arithmetic to algebraic expressions
98 I don’t know

155

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT GRADE 07 (air_t_scr_001_m_07 = 1).

Which of the following major topics are emphasized in the 7th grade mathematics class(es) you teach, according to your state standards for mathematics? ⁴⁷

SELECT ALL THAT APPLY

01 Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane
02 Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers
03 Use properties of operations to generate equivalent expressions
04 Generate the prime factorization of numbers to solve problems
98 I don’t know

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT GRADE 08 (air_t_scr_001_m_08 = 1).

Which of the following major topics are emphasized in the 8th grade mathematics class(es) you teach, according to your state standards for mathematics? ⁴⁷

SELECT ALL THAT APPLY

01 Represent and analyze quantitative relationships between dependent and independent variables
02 Define, evaluate, and compare functions
03 Understand and apply the Pythagorean Theorem
04 Understand that a set of data collected to answer a statistical question has a distribution, which can be described by its center, spread, and overall shape
98 I don’t know

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT ALGEBRA \( (\text{air_t_scr_004_m_01} = 1) \).

Which of the following major topics are emphasized in the Algebra course(s) you teach, according to your state standards for mathematics?\(^{48}\)

SELECT ALL THAT APPLY

01  Create equations and inequalities in one variable and use them to solve problems  
02  Solve quadratic equations in one variable  
03  Apply properties of operations as strategies to add, subtract, factor, and expand linear expressions with rational coefficients  
04  Use polar coordinates to describe locations on a plane  
98  I don’t know

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)) AND WHO INDICATED THEY TAUGHT GEOMETRY \( (\text{air_t_scr_004_m_02} = 1) \).

Which of the following major topics are emphasized in the Geometry course(s) you teach, according to your state standards for mathematics?\(^{48}\)

SELECT ALL THAT APPLY

**Geometry**

01  Experiment with transformations on the coordinate plane  
02  Identify the slope and the intercept of a linear model in the context of the data  
03  Explain and use the relationship between the sine and cosine of complementary angles  
04  Derive the formula for the sum of a finite geometric series and use the formula to solve problems  
98  I don’t know

UNIVERSE: RESPONDENTS WHO WERE ASSIGNED THE MATHEMATICS SUBJECT PATH (subject_path = 1 (Math)).

Content standards are often intended to address three types of student learning (e.g., sometimes called “aspects of rigor”) in relation to Common Core State Standards:

- **Conceptual understanding:** students know the meaning behind the math,
- **Procedural skill and fluency:** students can quickly and accurately perform operations, and
- **Application:** students apply their skills and knowledge in real world situations

Examine each standard carefully and check which of the above types of learning – or aspects of rigor – a teacher should particularly target in a lesson focused on this standard.49

<table>
<thead>
<tr>
<th>01</th>
<th>Fluently add and subtract within 20 using mental strategies. By end of Grade 2, know from memory all sums of two one-digit numbers</th>
<th>Conceptual understanding</th>
<th>Procedural skill and fluency</th>
<th>Application</th>
<th>I don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>98 □</td>
<td></td>
</tr>
</tbody>
</table>

| 02 | Relate counting to addition and subtraction (e.g., by counting on 2 to add 2)                                                   | 1 □                       | 2 □                         | 3 □         | 98 □        |

| 03 | Fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction | 1 □                       | 2 □                         | 3 □         | 98 □        |

<table>
<thead>
<tr>
<th></th>
<th>Conceptual understanding</th>
<th>Procedural skill and fluency</th>
<th>Application</th>
<th>I don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>04</strong></td>
<td>Interpret products of whole numbers, e.g., interpret (5 \times 7) as the total number of objects in 5 groups of 7 objects each. For example, describe a context in which a total number of objects can be expressed as (5 \times 7)</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>05</strong></td>
<td>Solve linear equations in one variable</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>06</strong></td>
<td>Identify when two expressions are equivalent (i.e., when the two expressions name the same number regardless of which value is substituted into them). For example, the expressions (y + y + y) and (3y) are equivalent because they name the same number regardless of which number (y) stands for</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Teacher Beliefs

Questions in this section ask about your beliefs regarding your standards, teaching, and learning.

SUBJECT WAS PREFILLED BASED ON THE ASSIGNED SUBJECT PATH.

UNIVERSE: ALL RESPONDENTS.

Indicate your agreement with the following statements about your state’s standards in [SUBJECT AREA]?  

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Teaching and learning that is aligned to the [SUBJECT AREA] standards prepares students for their future.</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>02</td>
<td>Teaching and learning that is aligned to the [SUBJECT AREA] standards gives students a deep understanding of the subject area.</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
<tr>
<td>03</td>
<td>Teaching and learning that is aligned to the [SUBJECT AREA] standards make class more engaging for students.</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>The [SUBJECT AREA] standards are too challenging for my students.</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
</tr>
<tr>
<td>05</td>
<td>The [SUBJECT AREA] standards make teaching less enjoyable.</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
</tr>
<tr>
<td>06</td>
<td>My students need something different than what is outlined in the [SUBJECT AREA] standards.</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
</tr>
<tr>
<td>07</td>
<td>My state’s standards in [SUBJECT AREA] make it difficult for students to learn basic skills in [SUBJECT AREA].</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
</tr>
<tr>
<td>08</td>
<td>My state’s standards in [SUBJECT AREA] provide educators a manageable number of topics to teach in a school year.</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
</tr>
<tr>
<td>09</td>
<td>I find myself skipping some standards-aligned [SUBJECT AREA] content in my instruction.</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
</tr>
<tr>
<td>10</td>
<td>The standards in [SUBJECT AREA] help me identify essential material to teach my students.</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
</tr>
<tr>
<td></td>
<td>Strongly disagree</td>
<td>Somewhat disagree</td>
<td>Somewhat agree</td>
<td>Strongly agree</td>
</tr>
<tr>
<td>---</td>
<td>------------------</td>
<td>------------------</td>
<td>---------------</td>
<td>----------------</td>
</tr>
<tr>
<td>11</td>
<td>The standards in [SUBJECT AREA] help <em>my</em> students achieve higher scores on district and/or state assessments.</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
</tr>
</tbody>
</table>
School Culture

Questions in this section ask about your school’s culture and educator perspectives at your school.

**UNIVERSE: ALL RESPONDENTS**

ROWS WITHIN TABLES WERE RANDOMIZED. THE ORDER OF THE TABLES WAS RANDOMIZED.

Indicate your agreement with the following statements about your experiences at your school this school year (2018-19).  

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>01</strong> People in this school are eager to share information about what does and does not work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>02</strong> Making mistakes is considered part of the learning process in this school.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>03</strong> In this school, teachers feel comfortable trying new, research-based teaching approaches.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>04</strong> In this school, it is easy to speak up about what is on my mind.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

---

<table>
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<th>Strongly disagree</th>
<th>Somewhat disagree</th>
<th>Somewhat agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>05</td>
<td>People in this school are usually comfortable talking about problems and disagreements about teaching and learning.</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
</tr>
<tr>
<td>06</td>
<td>Teachers in this school frequently observe other teachers and are comfortable being observed (even if the observation is unannounced).</td>
<td>1 ☐</td>
<td>2 ☐</td>
<td>3 ☐</td>
</tr>
</tbody>
</table>
Demographics

Questions in this section ask about your background, as well as additional information about students at your school.

UNIVERSE: ALL RESPONDENTS

Including this school year (2018-19), how long have you worked as a teacher? Please round to the nearest whole number, and do not include student teaching.

<table>
<thead>
<tr>
<th></th>
<th>YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>01</strong> Total amount of time teaching</td>
<td></td>
</tr>
<tr>
<td><strong>02</strong> Total amount of time teaching in current state</td>
<td></td>
</tr>
<tr>
<td><strong>03</strong> Total amount of time teaching in current district</td>
<td></td>
</tr>
<tr>
<td><strong>04</strong> Total amount of time teaching in current school</td>
<td></td>
</tr>
</tbody>
</table>

UNIVERSE: ALL RESPONDENTS

With which of the following do you identify?

SELECT ALL THAT APPLY

- **04** American Indian or Alaska Native
- **05** Asian
- **03** Black or African American
- **01** Hispanic, Latino, or Spanish origin
- **06** Native Hawaiian or other Pacific Islander
In what area(s) are you certified to teach in your state?

SELECT ALL THAT APPLY

01 Specific subject areas (K-12) (specify): 
02 Elementary education 
03 English language learners (K-12) 
04 Special education 
91 Other (please specify): 

In what field was your undergraduate major/s?

SELECT ALL THAT APPLY

01 Arts (Visual & Performing) 
02 Area and/or Ethnic Studies 
03 Communications and/or Journalism 
04 Computer Science 
05 Biology, Biological Sciences and/or Medicine 
06 Business 
07 Economics 
08 Education 
09 Engineering 
10 English Language & Literature 
11 Gender Studies 
12 History 
13 Internal Relations and/or Diplomacy 
14 Languages & Linguistics 
15 Mathematics 
16 Natural Sciences 
17 Liberal Arts 
18 Philosophy 
19 Physical Education 
20 Religion
In what field was your graduate degree?

SELECT ALL THAT APPLY

99 N/A - I do not have a graduate degree.
01 Arts (Visual & Performing)
02 Area and/or Ethnic Studies
03 Communications and/or Journalism
04 Computer Science
05 Biology, Biological Sciences and/or Medicine
06 Business
07 Economics
08 Education
09 Engineering
10 English Language & Literature
11 Gender Studies
12 History
13 Internal Relations and/or Diplomacy
14 Languages & Linguistics
15 Mathematics
16 Natural Sciences
17 Liberal Arts
18 Philosophy
19 Physical Education
20 Religion
21 Social Sciences
22 Technology
91 Other (please specify): ______________
The next few questions relate to the characteristics of the students you teach. We ask these questions to better understand the context in which you are teaching and the unique challenges you may face for the classes you teach.

**air_t_dem_413_s_00**

**UNIVERSE: ALL RESPONDENTS**

Approximately, what percentage of the students you teach—including those in small push-in or pull-out groups—are English Language Learners?\(^\text{52}\)?

1. 10% or less
2. 11%-24%
3. 25%-49%
4. 50%-74%
5. 75-100%

**air_t_dem_414_s_00**

**UNIVERSE: ALL RESPONDENTS**

Approximately, what percentage of the students you teach have an Individualized Education Program (IEP)\(^\text{53}\) and/or 504 Plan?\(^\text{54}\)?

1. 10% or less
2. 11%-24%
3. 25%-49%
4. 50%-74%
5. 75-100%

---

\(^{52}\) HOVER-OVER DEFINITION OF “English Language Learners”: English Language Learners are students who come from non-English speaking homes and who are learning English

\(^{53}\) HOVER-OVER DEFINITION OF “Individualized Education Program”: Individualized Educational Plan (IEP) is a plan or program developed to ensure that a child who has a disability identified under the law receives specialized instruction and related services

\(^{54}\) HOVER-OVER DEFINITION OF “504 plan”: Individualized Educational Plan (IEP) is a plan or program developed to ensure that a child who has a disability identified under the law receives specialized instruction and related services
Approximately, what percentage of the students you teach meet each of the following categories?

<table>
<thead>
<tr>
<th></th>
<th>10% or less</th>
<th>11%-24%</th>
<th>25%-49%</th>
<th>50%-74%</th>
<th>75-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 American Indian or Alaska Native</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td>02 Asian</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td>03 Black or African American</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td>04 Hispanic/Latino</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td>05 Native Hawaiian or Other Pacific Islander</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td>06 Two or more races</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
<tr>
<td>07 White</td>
<td>1 □</td>
<td>2 □</td>
<td>3 □</td>
<td>4 □</td>
<td>5 □</td>
</tr>
</tbody>
</table>

Please indicate how much time you spent completing this survey: __________ minutes

With which of the following do you identify?

1 Male
2 Female
91 Other

[END SURVEY]
References


Appendix D. R-Code: Data Preparation

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Preparation

Load Packages
library(tidyverse)

## ── Attaching packages ─────────────────────────────────────── tidyverse 1.3.2 ──
## ✔ ggplot2 3.3.6
## ✔ purrr 0.3.4
## ✔ tibble 3.1.7
## ✔ dplyr 1.0.9
## ✔ tidyr 1.2.0
## ✔ stringr 1.4.0
## ✔ forcats 0.5.1

## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
## ✗ dplyr::filter() masks stats::filter()
## ✗ dplyr::lag() masks stats::lag()

library(readxl)
library(furniture)
library(psych)

##
## ── Attaching package: 'psych'
Import RAND Datasets

```r
rand_restrict <- read.csv("RAND AIRS 2019/RAND2019_05MAY_AIR0519T_JH.csv")

dplyr::select(respondent_id, weight, weight_state, subject = SUBJECT_PATH, #AIR_T_SCR_002_M_01, mathematics filter?
band = GRADES, #grade band ...where the survey RO
UTED them!
pct_frpl, #ses THIS HAS 4 LEVELS! *about 50 are B
LANK?!
exp = AIR_T_DEM_401_C_01, #teacher experience
starts_with("AIR_T_CMM_604_A_7"), #programs used
starts_with("AIR_T_CMM_608_G_7") #choice
)
tibble::glimpse(rand_restrict)
```

```
## Rows: 5,969
## Columns: 159
## $ respondent_id          <chr> "T864942", "T966789", "T851177"
## $ weight                 <dbl> 1262.061441, 23.445535, 1078.27
## $ weight_state           <chr> "Other", "LA", "Other", "Other"
## $ subject                <int> 1, 2, 2, 1, 2, 3, 3, 2, 1, 1, 2
## $ band                   <int> 1, 2, 3, 1, 1, 3, 1, 1, 1, 1, 1
## $ pct_frpl               <chr> "", "", "", "", "", "", "", "", "", ""
## $ exp                    <int> 7, 10, 14, 19, 4, 7, 12, 6, 8, 5, 10, 7, 4, 20,
## $ AIR_T_CMM_604_A_703_01 <int> 0, -888, -888, 0, -888, -888, -888, -888, 0, 0, -888, -888, 0, -888, -888, -888,
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</tbody>
</table>
## Import Features of each Program

```r
data_features_JH <- readxl::read_excel("Features_7-29-22.xlsx", 
  range = "A2:H31") %>%
  dplyr::mutate(rater = "JH")

data_features_EM <- readxl::read_excel("Features_9-18-22_EM.xlsx", 
  range = "A2:H31") %>%
  dplyr::mutate(rater = "EM")

data_features_both <- dplyr::full_join(data_features_JH, 
  data_features_EM)

# Joining, by = c("program", "program_name", "videos", "interactive", 
# "adaptive", "creatorevise", "parent", "rater")

data_feature_long <- data_features_both %>%
  tidyr::pivot_longer(cols = videos:parent, 
  names_to = "featureid", 
  values_to = "endorsed") %>%
```
```r
tidyr::pivot_wider(names_from = rater, 
                  values_from = endorsed) %>%
dplyr::mutate(agree = (JH == EM))

data_feature_long %>%
dplyr::select(agree) %>%
table(useNA = "always") %>%
addmargins()

## agree
##    0    1 <NA>  Sum
##   89   73   12  174

Not agreed

data_feature_long %>%
dplyr::filter(JH != EM)

## # A tibble: 34 × 6
## # row.names  program program_name featureid       JH   EM agree
##     <int> <chr>        <chr>          <dbl> <dbl> <dbl>
##  1     703 ALEKS        parent          1     0     0
##  2     704 Amplify      adaptive        0     1     1
##  3     709 Desmos       practice        0     1     1
##  4     709 Desmos       createrevise    1     0     0
##  5     711 Edcite       videos          1     0     0
##  6     711 Edcite       interactive     1     0     0
##  7     714 Freckle      interactive     0     1     1
##  8     717 i-Ready      videos          1     0     0
##  9     717 i-Ready      interactive     1     0     0
##10     717 i-Ready      createrevise    1     0     0
## # … with 24 more rows
## # ℹ Use `print(n = ...)` to see more rows

data_feature_long %>%
dplyr::select(JH, EM, featureid) %>%
table(useNA = "always") %>%
addmargins()

## , , featureid = adaptive
##
## ## JH  EM
## ## 0     0 1 1 <NA> Sum
## ## 1    10 6 1 17
## ## 1     2 9 1 12
## ## <NA>  0 0 0 0
## ## Sum 12 15 2 29
##
```
### , , featureid = createrevise
```r
## EM
## JH  0  1 <NA> Sum
## 0  18  0  2  20
## 1  2  7  0  9
## <NA> 0  0  0  0
## Sum 20  7  2  29
```
### , , featureid = interactive
```r
## EM
## JH  0  1 <NA> Sum
## 0  11  5  0  16
## 1  3  8  2  13
## <NA> 0  0  0  0
## Sum 14 13  2  29
```
### , , featureid = parent
```r
## EM
## JH  0  1 <NA> Sum
## 0  18  1  1  20
## 1  5  3  1  9
## <NA> 0  0  0  0
## Sum 23 4  2  29
```
### , , featureid = practice
```r
## EM
## JH  0  1 <NA> Sum
## 0  1  1  1  3
## 1  1  24  1  26
## <NA> 0  0  0  0
## Sum 2 25  2  29
```
### , , featureid = videos
```r
## EM
## JH  0  1 <NA> Sum
## 0  12  2  2  16
## 1  6  7  0  13
## <NA> 0  0  0  0
## Sum 18 9  2  29
```
### , , featureid = NA
If you decide that EM was wrong and JH was correct in all disagreements, revise this if there are some changes that need to happen.

data_features_new <- readxl::read_excel("Features_9-26-22.xlsx", range = "A2:H31")

data_features_new

# A tibble: 29 × 8
#program program_name videos interactive practice adaptive
#<dbl> <chr>           <dbl>       <dbl>    <dbl>    <dbl>
createre...¹ parent
#<dbl> <chr>           <dbl>       <dbl>    <dbl>    <dbl>
## 1 703 ALEKS               0        0        1        1
## 2 704 Amplify             0        1        1        0
## 3 705 ASSISTments         0        0        1        0
## 4 706 BrainPOP            1        1        1        0
## 5 707 ck-12              1        1        1        1
## 6 709 Desmos              0        1        0        0
## 7 710 Dreambox            0        1        0        1
## 8 711 Edcite              1        1        1        0
## 9 714 Freckle             1        0        1        1
Data Wrangling

Respondent Demographics: N = 2027

```r
data_respondent <- rand_restrict %>%
dplyr::rename(id = respondent_id) %>%
dplyr::filter(subject == 1) %>%
  dplyr::mutate(weight_state = weight_state %>%
                 factor()) %>%
  forcats::fct_relevel("Other", after = Inf)) %>%
  dplyr::mutate(band = factor(band,
                        levels = 1:3,
                        labels = c("Elementary",
                                   "Middle School",
                                   "High School"))) %>%
  dplyr::mutate(pct_frpl = pct_frpl %>%
                 factor()) %>%
  forcats::fct_recode(NULL = " ",
                     "0-25%" = "1. 00.0% - 25.0%",
                     "25-50%" = "2. 25.1% - 50.0%",
                     "50-75%" = "3. 50.1% - 75.0%",
                     "75-100%" = "4. 75.1% -100.0%") %>%
  dplyr::mutate(exp = na_if(exp, -999)) %>%
  dplyr::mutate(subset = case_when(!is.na(exp) & !is.na(pct_frpl) ~ "Complete",
                                   is.na(exp) & !is.na(pct_frpl) ~ "Missing Experience",
                                   !is.na(exp) & is.na(pct_frpl) ~ "Missing Lunch"))
nrow(data_respondent)
```

## [1] 2027
Program Endorsement & Choice: N = 29 x 2027 = 58783

data_program_respondent <- data_respondent %>%
tidyr::pivot_longer(cols = starts_with("AIR"),
  names_to = c("type", "program", "subtype"),
  names_pattern = "AIR_T_CMM_60(._.)(...)_.(.*)") %>%
dplyr::mutate(type = type %>%
  factor() %>%
  forcats::fct_recode("how" = "4_A",
  "choice" = "8_G") %>%
tidyr::unite(col = "var",
  type, subtype) %>%
dplyr::filter(program != 791) %>%
dplyr::filter(program != 799) %>%
dplyr::mutate(value = na_if(value, -999)) %>%
dplyr::mutate(value = na_if(value, -880)) %>%
dplyr::mutate(value = na_if(value, -888)) %>%
tidyr::pivot_wider(names_from = var,
  values_from = value) %>%
dplyr::mutate(use = pmax(how_01, how_02, na.rm = TRUE) %>%
  factor(levels = 0:1,
  labels = c("No", "Yes"))) %>%
dplyr::mutate(choice = pmax(choice_E, choice_M, choice_H, na.rm = TRUE) %>%
  factor(levels = 1:3,
  labels = c("Required", "Recomended", "Neither"))) %>%
dplyr::select(-how_01, -how_02,
  -choice_E, -choice_M, -choice_H) %>%
dplyr::group_by(id) %>%
dplyr::mutate(num_use = sum((use == "Yes"))) %>%
dplyr::mutate(num_req = sum((choice == "Required"), na.rm = TRUE)) %>%
dplyr::mutate(num_rec = sum((choice == "Recomended"), na.rm = TRUE)) %>%
dplyr::mutate(num_nth = sum((choice == "Neither"), na.rm = TRUE)) %>%
dplyr::ungroup() %>%
dplyr::mutate(program = as.numeric(program)) %>%
dplyr::left_join(data_features_new, by = "program") %>%
dplyr::mutate(some_req = case_when(choice == "Required" ~ 1,
  choice != "Required" ~ 0)) %
```r
# Load necessary packages
library(dplyr)
library(tidyr)

# Data manipulation
num_use <- ifelse(is.na(num_use), 0, num_use)

nrow(data_program_respondent)
## [1] 58783

# Filter data
2027*29
## [1] 58783

id_noprog <- data_respondent
  %>% tidyr::pivot_longer(cols = starts_with("AIR"),
                         names_to = c("type", "program", "subtype"),
                         names_pattern = "AIR_T_CMM_60(._.)_(...)_(. *)")
  %>%
  dplyr::mutate(type = type %>%
                factor() %>%
               forcats::fct_recode("how" = "4_A",
                                    "choice" = "8_G"))
  %>%
  tidyr::unite(col = "var",
               type, subtype)
  %>%
  dplyr::filter(var %in% c("how_01", "how_02"))
  %>%
  dplyr::filter(program == 799)
  %>%
  dplyr::group_by(id)
  %>%
  dplyr::summarise(none = sum(value))
  %>%
  dplyr::ungroup()
  %>%
  dplyr::filter(none > 0)
  %>%
  dplyr::pull(id)

length(id_noprog)
## [1] 392

id_otherprog <- data_respondent
  %>% tidyr::pivot_longer(cols = starts_with("AIR"),
                         names_to = c("type", "program", "subtype"),
                         names_pattern = "AIR_T_CMM_60(._.)_(...)_(. *)")
  %>%
  dplyr::mutate(type = type %>%
                factor() %>%
               forcats::fct_recode("how" = "4_A",
                                    "choice" = "8_G"))
  %>%
  tidyr::unite(col = "var",
               type, subtype)
  %>%
  dplyr::filter(var %in% c("how_01", "how_02"))
  %>%
  dplyr::filter(program == 791)
```

---

The code above is a data manipulation script using the `dplyr` and `tidyr` packages in R. It performs various operations such as data transformation, filtering, and summarization. The `id_noprog` and `id_otherprog` datasets are generated from the `data_respondent` dataset through a series of steps involving `mutate`, `pivot_longer`, and `filter` functions.
```r
dplyr::group_by(id) %>%
dplyr::summarise(some = sum(value)) %>%
dplyr::ungroup() %>%
dplyr::filter(some > 0) %>%
dplyr::pull(id)

length(id_otherprog)
## [1] 362

data_demo <- data_program_respondent %>%
dplyr::group_by(id) %>%
dplyr::slice(1) %>%
dplyr::ungroup() %>%
dplyr::select(id, subset, weight, weight_state, band, exp, pct_frpl, starts_with("num"))

data_demo %>%
dplyr::select(num_use) %>%
table(useNA = "always") %>%
addmargins()

## num_use
##    0    1    2    3    4    5    6    7    8    9   10   11
## 12 13 27 29
## 323 370 430 362 253 137 77 38 16  9  6  2
##  1  1  1  1
## <NA> Sum
##    0 2027

Of the N = 2027 Math teachers, 323 did not endorse using any of the 29 programs

data_program_respondent %>%
dplyr::select(use, some_req) %>%
table(useNA = "always") %>%
addmargins()

## some_req
## use      0   1 <NA> Sum
## No       0  0   0  53409 53409
## Yes 4449 647  17  5113
## <NA>   0  0  261  261
## Sum 4449 647 53687 58783
```
Features of Programs, $N = 6 \times 29 \times 2027 = 352698$

data_feature_program_respondent <- data_program_respondent %>%
tidyr::pivot_longer(cols = c(videos, interactive, practice, adaptive, createrevise, parent),
  names_to = "feature",
  values_to = "contain")

nrow(data_feature_program_respondent)
## [1] 352698

$6 \times 29 \times 2027$
## [1] 352698

Collapse across Program

data_feature_req_use <- data_feature_program_respondent %>%
dplyr::filter(use == "Yes") %>%
dplyr::group_by(id, feature, some_req) %>%
dplyr::summarize(count = sum(contain)) %>%
dplyr::ungroup() %>%
dplyr::mutate(use_any = case_when(count >= 1 ~ 1,
  count == 0 ~ 0)) %>%
dplyr::select(-count) %>%
dplyr::mutate(some_req = ifelse(use_any == 0, 0, some_req)) %>%
dplyr::arrange(id, feature, desc(some_req)) %>%
dplyr::group_by(id, feature) %>%
dplyr::slice(1) %>%
dplyr::ungroup()

N = (2027 - 323) \times 6 = 1704 \times 6 = 10224

data_feature_req_use %>%
dplyr::select(some_req, use_any) %>%
table(useNA = "always") %>%
addmargins()
## use_any
## some_req 0 1 <NA> Sum
## 0 2748 5314 0 8062
## 1 0 2133 0 2133
## <NA> 0 29 0 29
## Sum 2748 7476 0 10224

Note: there are 1704 respondents using at least one program. Of the 7476 endorsements of features, 29 are missing the “required” status.

**Final Long Format**

\[ N = (1704) \times 6 + (323 \times 1) = 10547 \]

data_feature <- data_demo %>%
dplyr::left_join(data_feature_req_use, by = "id") %>%
dplyr::mutate_at(vars(id, subset, feature), factor) %>%
dplyr::mutate(type_user = case_when(num_use > 0 ~ "User of 29 Programs",
                                id %in% id_otherprog ~ "Only Used Other Programs",
                                id %in% id_noprog ~ "Non-user of ALL Programs",
                                is.na(feature) ~ "Broke Protocol"))

data_feature

### A tibble: 10,547 × 15
### id subset weight weight_¹ band exp pct_f...² num_use num_req num_rec
### <fct> <fct> <dbl> <fct> <fct> <fct> <fct> <fct> <fct> <fct> <fct>
### 1 T000298 Complete 27.4 NM Elem... 17 50-75% 2 0
### 2 T000298 Complete 27.4 NM Elem... 17 50-75% 2 0
### 3 T000298 Complete 27.4 NM Elem... 17 50-75% 2 0
### 4 T000298 Complete 27.4 NM Elem... 17 50-75% 2 0
### 5 T000298 Complete 27.4 NM Elem... 17 50-75% 2 0
### 6 T000298 Complete 27.4 NM Elem... 17 50-75% 2 0
data_nonuser <- data_feature %>%
dplyr::filter(is.na(feature)) %>%
dplyr::mutate(videos = 0,
               interactive = 0,
               practice = 0,
               adaptive = 0,
               createrevise = 0,
               parent = 0) %>%
dplyr::select(-feature, -use_any) %>%
tidyr::pivot_longer(cols = c(videos,
                       interactive,
                       practice,
                       adaptive,
                       createrevise,
                       parent),
               names_to = "feature",
               values_to = "use_any") %>%
dplyr::mutate(some_req = 0)

nrow(data_nonuser)
## [1] 1938

6*232
## [1] 1392
data_feature %>%
dplyr::group_by(id) %>%
dplyr::slice(1) %>%
dplyr::ungroup() %>%
dplyr::select(type_user) %>%
table(useNA = "always") %>%
addmargins()

## type_user
##                 Broke Protocol Non-user of ALL Programs Only Used Other Programs
##                  20                       223
##                 80
## User of 29 Programs <NA>
## Sum
##                  1704                        0
##                 2027

N = 1704 users * 6 = 10224 N = 323 non-users * 6 = 1938 together: 2027*6 = 12162

data_long <- data_feature %>%
dplyr::filter(!is.na(feature)) %>%
dplyr::full_join(data_nonuser) %>%
dplyr::arrange(id, feature) %>%
dplyr::mutate_at(vars(feature, some_req, use_any, type_user),
                 factor) %>%
dplyr::mutate_at(vars(some_req, use_any),
                 forcats::fct_recode,
                 "Yes" = "1",
                 "No" = "0") %>%

## Joining, by = c("id", "subset", "weight", "weight_state", "band",
## "exp",
## "pct_frpl", "num_use", "num_req", "num_rec", "num_nth", "feature",
## "some_req",
## "use_any", "type_user")

## Joining, by = c("id", "subset", "weight", "weight_state", "band",
## "exp",
## "pct_frpl", "num_use", "num_req", "num_rec", "num_nth", "feature",
## "some_req",
## "use_any", "type_user")

#JH

# dplyr::rename(choice = some_req) %>% #need to switch yes and no because yes choice means no required programs for that feature.
# dplyr::rename (access = use_any)# %>%
# order(levels(featureid))

data_long
tibble::glimpse(data_long)

## Rows: 12,162
## Columns: 15
## $ id           <fct> T000298, T000298, T000298, T000298, T000298, T000298, T000298, T000298, T000298, T000298, T000298, T000298, T000298, T000298, T000298
## Descriptives

N = 2027 Math teachers, 46 are missing experience & 27 are missing free/reduced lunch

## Demographics

data_demo %>%
  dplyr::select(weight, exp) %>%
  psych::describe(skew = FALSE)

```r
#> # A tibble: 2 × 7
#>    vars     n mean     sd     min     max range  se
#>  <chr> <int> <dbl> <dbl>  <dbl>  <dbl> <dbl> <dbl>
1 weight 2027 379.8  437.97 1931.92 1926.97  9.73
2 exp    1981 14.52  8.29  1.00  47.00  46.00  0.19
```

```r
data_demo %>%
  furniture::table1("Number Programs (29)" = as.factor(num_use),
```
band, #grade band ...where the survey ROUTED them!
pct_frpl, #ses THIS HAS 4 LEVELS! *about 50 a re BLANK?!

exp, #teacher experience
weight,
weight_state,
splitby = ~ subset,
output = "markdown",
total = TRUE,
test = TRUE,
na.rm = FALSE)

## The test is for the stratified data relationships.

## Warning in chisq.test(d$split, d[[i]]): Chi-squared approximation may be
## incorrect

## Warning in chisq.test(d$split, d[[i]]): Chi-squared approximation may be
## incorrect

<table>
<thead>
<tr>
<th>Number Programs</th>
<th>Total</th>
<th>Complete</th>
<th>Missing Experience</th>
<th>Missing Lunch</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(29)</td>
<td>n = 2027</td>
<td>n = 1954</td>
<td>n = 46</td>
<td>n = 27</td>
<td>0.278</td>
</tr>
<tr>
<td>0</td>
<td>323 (15.9%)</td>
<td>304 (15.6%)</td>
<td>15 (32.6%)</td>
<td>4 (14.8%)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>370 (18.3%)</td>
<td>363 (18.6%)</td>
<td>4 (8.7%)</td>
<td>3 (11.1%)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>430 (21.2%)</td>
<td>413 (21.1%)</td>
<td>11 (23.9%)</td>
<td>6 (22.2%)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>362 (17.9%)</td>
<td>345 (17.7%)</td>
<td>6 (13%)</td>
<td>11 (40.7%)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>253 (12.5%)</td>
<td>246 (12.6%)</td>
<td>5 (10.9%)</td>
<td>2 (7.4%)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>137 (6.8%)</td>
<td>136 (7%)</td>
<td>0 (0%)</td>
<td>1 (3.7%)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>77 (3.8%)</td>
<td>73 (3.7%)</td>
<td>4 (8.7%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>38 (1.9%)</td>
<td>38 (1.9%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>16 (0.8%)</td>
<td>16 (0.8%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Complete</td>
<td>Missing Experience</td>
<td>Missing Lunch</td>
<td>P-Value</td>
</tr>
<tr>
<td>-------</td>
<td>---------</td>
<td>----------</td>
<td>--------------------</td>
<td>---------------</td>
<td>---------</td>
</tr>
<tr>
<td>9</td>
<td>9 (0.4%)</td>
<td>8 (0.4%)</td>
<td>1 (2.2%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>6 (0.3%)</td>
<td>6 (0.3%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>2 (0.1%)</td>
<td>2 (0.1%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1 (0%)</td>
<td>1 (0.1%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1 (0%)</td>
<td>1 (0.1%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>1 (0%)</td>
<td>1 (0.1%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>1 (0%)</td>
<td>1 (0.1%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>NA</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>band</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.855</td>
</tr>
<tr>
<td>Elementary</td>
<td>1083 (53.4%)</td>
<td>1045 (53.5%)</td>
<td>23 (50%)</td>
<td>15 (55.6%)</td>
<td></td>
</tr>
<tr>
<td>Middle School</td>
<td>502 (24.8%)</td>
<td>485 (24.8%)</td>
<td>10 (21.7%)</td>
<td>7 (25.9%)</td>
<td></td>
</tr>
<tr>
<td>High School</td>
<td>442 (21.8%)</td>
<td>424 (21.7%)</td>
<td>13 (28.3%)</td>
<td>5 (18.5%)</td>
<td></td>
</tr>
<tr>
<td>NA</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>pct_frpl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.151</td>
</tr>
<tr>
<td>0-25%</td>
<td>459 (22.6%)</td>
<td>448 (22.9%)</td>
<td>11 (23.9%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>25-50%</td>
<td>710 (35%)</td>
<td>696 (35.6%)</td>
<td>14 (30.4%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>50-75%</td>
<td>499 (24.6%)</td>
<td>491 (25.1%)</td>
<td>8 (17.4%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>75-100%</td>
<td>332 (16.4%)</td>
<td>319 (16.3%)</td>
<td>13 (28.3%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>NA</td>
<td>27 (1.3%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>27 (100%)</td>
<td></td>
</tr>
<tr>
<td>exp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.122</td>
</tr>
<tr>
<td>14.5 (8.3)</td>
<td>14.6 (8.3)</td>
<td>NaN (NA)</td>
<td>12.1 (9.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.009</td>
</tr>
<tr>
<td>379.8 (438.0)</td>
<td>376.7 (437.0)</td>
<td>363.7 (395.2)</td>
<td>636.1 (511.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>weight_state</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.143</td>
</tr>
<tr>
<td>CA</td>
<td>132 (6.5%)</td>
<td>129 (6.6%)</td>
<td>0 (0%)</td>
<td>3 (11.1%)</td>
<td></td>
</tr>
<tr>
<td>DE</td>
<td>120 (5.9%)</td>
<td>117 (6%)</td>
<td>3 (6.5%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>FL</td>
<td>125 (6.2%)</td>
<td>123 (6.3%)</td>
<td>1 (2.2%)</td>
<td>1 (3.7%)</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td>Total</td>
<td>Complete</td>
<td>Experience</td>
<td>Lunch</td>
<td>P-Value</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>----------</td>
<td>------------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>LA</td>
<td>129 (6.4%)</td>
<td>122 (6.2%)</td>
<td>3 (6.5%)</td>
<td>4 (14.8%)</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>126 (6.2%)</td>
<td>122 (6.2%)</td>
<td>3 (6.5%)</td>
<td>1 (3.7%)</td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>114 (5.6%)</td>
<td>112 (5.7%)</td>
<td>1 (2.2%)</td>
<td>1 (3.7%)</td>
<td></td>
</tr>
<tr>
<td>NE</td>
<td>128 (6.3%)</td>
<td>126 (6.4%)</td>
<td>2 (4.3%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>NM</td>
<td>143 (7.1%)</td>
<td>138 (7.1%)</td>
<td>3 (6.5%)</td>
<td>2 (7.4%)</td>
<td></td>
</tr>
<tr>
<td>NY</td>
<td>130 (6.4%)</td>
<td>123 (6.3%)</td>
<td>6 (13%)</td>
<td>1 (3.7%)</td>
<td></td>
</tr>
<tr>
<td>RI</td>
<td>123 (6.1%)</td>
<td>120 (6.1%)</td>
<td>2 (4.3%)</td>
<td>1 (3.7%)</td>
<td></td>
</tr>
<tr>
<td>TN</td>
<td>138 (6.8%)</td>
<td>133 (6.8%)</td>
<td>4 (8.7%)</td>
<td>1 (3.7%)</td>
<td></td>
</tr>
<tr>
<td>WI</td>
<td>116 (5.7%)</td>
<td>109 (5.6%)</td>
<td>7 (15.2%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>503 (24.8%)</td>
<td>480 (24.6%)</td>
<td>11 (23.9%)</td>
<td>12 (44.4%)</td>
<td></td>
</tr>
<tr>
<td>NA</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
</tbody>
</table>

```r

data_wide <- data_long %>%
tidyr::pivot_wider(names_from = feature, values_from = c(some_req, use_any))
```

**data_wide**

```
## A tibble: 2,027 × 24
## # id     subset   weight weight_experience band   exp pct_f体验 num_requests num_records
## <fct>    <fct>     <dbl>     <fct>          <int> <fct> <fct>      <int> <int>
## 1 T000298 Complete 27.4 NM     Elem... 17 50-75%   
## 2 T002113 Complete 872. Other High... 10 0-25%    
## 3 T002750 Complete 983. Other Elem... 5 50-75%    
## 4 T004144 Complete 943. Other Elem... 5 0-25%     
## 5 T006283 Complete 621. Other Midd... 7 50-75%    
## 6 T007132 Complete 38.9 MS      Elem... 6 50-75%    
## 7 T007651 Complete 18.0 DE      Midd... 18 25-50%    
## 8 T007900 Complete 817. Other High... 13 0-25%    
## 9 T008150 Complete 194. FL      High... 12 50-75%    
##   ```
## 10 T008874 Complete 30.9 NM High... 17 25-50%

1 0 0

... with 2,017 more rows, 14 more variables: num_nth <int>, type_user <fct>,

some_req_adaptive <fct>, some_req_createrevise <fct>,
some_req_interactive <fct>, some_req_parent <fct>, some_req_practice <fct>,
some_req_videos <fct>, use_any_adaptive <fct>, use_any_createrevise <fct>,
use_any_interactive <fct>, use_any_parent <fct>, use_any_practice <fct>,
use_any_videos <fct>, and abbreviated variable names

¹ weight_state,
² pct_frpl

ℹ Use `print(n = ...)` to see more rows, and `colnames()` to see all variable names

save(data_wide,
     data_long,
     file = "RAND_preped_data_9-27-22.RData")
Appendix E. R-Code: Data Analysis

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Preparation

Load Packages

```r
# -- Attaching packages -------------------------------------- tidyverse 1.3.2 --
# ✓ ggplot2 3.3.6 ✓ purrr 0.3.4
# ✓ tibble 3.1.7 ✓ dplyr 1.0.9
# ✓ tidyr 1.2.0 ✓ stringr 1.4.0
# ✓ readr 2.1.2 ✓ forcats 0.5.1
# -- Conflicts -------------------------------------- tidyverse_conflicts() --
# × dplyr::filter() masks stats::filter()
# × dplyr::lag() masks stats::lag()
#
# Attaching package: 'psych'
#```

## The following object is masked from 'package:furniture':
## tableF

## The following objects are masked from 'package:ggplot2':
## %+, alpha

## Loading required package: Matrix

## Attaching package: 'Matrix'

## The following objects are masked from 'package:tidyr':
## expand, pack, unpack

## Loading required package: carData

## Attaching package: 'car'

## The following object is masked from 'package:psych':
## logit

## The following object is masked from 'package:dplyr':
## recode

## The following object is masked from 'package:purrr':
## some

## Version: 1.38.6
## Date: 2022-04-06
## Author: Philip Leifeld (University of Essex)
## Consider submitting praise using the praise or praise_interactive functions.
## Please cite the JSS article in your publications -- see citation("texreg").
##
## Attaching package: 'texreg'
##
## The following object is masked from 'package:tidyr':
## extract

**Custom Function**

```r
pval_label_apa <- function(value, 
breaks = c(.05, .01, .001), 
symbols = c("*", "**", "***"), 
decimals = 3, 
leading = FALSE)

value_apa = MOTE::apa(value = value, 
decimals = decimals, 
leading = leading)

value_apa_min = MOTE::apa(value = breaks[3], 
decimals = decimals, 
leading = leading)

dplyr::case_when(value < breaks[3] ~ glue::glue("p < {value_apa_min} {symbols[3]}"), 
value == breaks[3] ~ glue::glue("p = {value_apa_min} {symbols[3]}"), 
value <= breaks[2] ~ glue::glue("p = {value_apa} {symbols[2]}"), 
value <= breaks[1] ~ glue::glue("p = {value_apa} {symbols[1]}"), 
value > breaks[1] ~ glue::glue("p = {value_apa}"))
```

**Load Data**

```r
load("RAND_preped_data_9-27-22.RData")
data_long_JH <- data_long %>%
dplyr::select(weight, weight_state, id,
```
feature, band, pct_frpl, exp, some_req, use_any, type_user

dplyr::rename(access = use_any) %>%
dplyr::mutate(accessN = ifelse(access=="Yes",1,0)) %>%

dplyr::rename(teacherid = id) %>%
dplyr::mutate(featureid = feature %>%
  factor(levels=c("videos", "interactive", "practice", "adaptive", "create/revise", "parent"),
  labels=c("Videos", "Interactive", 'Practice', 'Adaptive', 'Create/Revise', "Parent"))) %>%

dplyr::rename(gradeband = band) %>%
dplyr::mutate(ses = pct_frpl %>%
 forcats::fct_recode("High" = "0-25%", #High SES means Low %FRPL
  "Med-high" = "25-50%",
  "Med-low" = "50-75%",
  "Low" = "75-100%")) %>%

dplyr::mutate(ses2 = pct_frpl %>%
 forcats::fct_recode("High" = "0-25%",
  "High" = "25-50%",
  "Low" = "50-75%",
  "Low" = "75-100%")) %>%

dplyr::mutate(choiceN = ifelse(some_req=="Yes",0,1)) %>%
dplyr::mutate(choice = choiceN %>%
  factor(levels = 0:1,
  labels= c("No", "Yes"))) %>%

#Exclusion:
dplyr::filter(type_user != "Only Used Other Programs") %>%
dplyr::filter(type_user != "Broke Protocol") %>%
#dplyr::filter(!teacherid %in% c("T082791", "T120952", "T139821")) %>% #missing choice...dropped choice so keep them in.
dplyr::filter(complete.cases(exp, ses, ses2))

data_long_JH %>%
tibble::glimpse() #11184

## Rows: 11,184
## Columns: 16
Fit Full includes the choice variable which has missing data. This filters out those three entire teachers to show and discuss fit_full.

data_long_JH_f <- data_long_JH %>%
  dplyr::filter(!teacherid %in% c("T082791", "T120952", "T139821"))

data_long_JH_f %>%
tibble::glimpse() #11166

## Rows: 11,166
## Columns: 16
## $ weight       <dbl> 27.42666, 27.42666, 27.42666, 27.42666, 2
## $ weight_state <fct> NM, NM, NM, NM, NM, Other, Other, Other...
## $ teacherid    <fct> T000298, T000298, T000298, T000298, T0002...
## $ feature      <fct> adaptive, create/revise, interactive, parent, practice, vi...
## $ gradeband    <fct> Elementary, Elementary, Elementary, Elementary, Elementary...
## $ pct_frpl     <fct> 50-75%, 50-75%, 50-75%, 50-75%, 50-75%, 50-75%, 50-75%, 50-75..., 50-75%, 50-75%, 50-75%, 50-75%, 50-75%, ...
## $ exp          <int> 17, 17, 17, 17, 17, 17, 17, 17, 17, 17, 17, 17, 17, 17, 17, ...
## $ some_req     <fct> Yes, Yes, Yes, No, Yes, Yes, No, No, No, No, No, ...
## $ access       <fct> Yes, Yes, Yes, No, Yes, Yes, No, No, No, No, ...
## $ type_user    <fct> User of 29 Programs, User of 29 Programs, ...
## $ accessN      <dbl> 1, 1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, ...
## $ featureid    <fct> Adaptive, Create/Revise, Interactive, Parent, Practice, ...
## $ ses          <fct> Med-low, Med-low, Med-low, Med-low, Med-low, Med-low, ...
## $ ses2         <fct> Low, Low, Low, Low, Low, High, High, High, ...
## $ choiceN      <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ...
## $ choice       <fct> No, No, No, Yes, No, No, Yes, Yes, Yes, Yes, Yes, Yes, Y...
200

7.42666, 27.4266...

## $ weight_state <fct> NM, NM, NM, NM, NM, Other, Other, Other, Oth-
er, Other, Other, Other...
## $ teacherid <fct> T000298, T000298, T000298, T000298, T00029-
8, T000298, T00...
## $ feature <fct> adaptive, createrevise, interactive, parent, practice, vi-
## $ gradeband <fct> Elementary, Elementary, Elementary, Elementary, Eleme-
tary, Elementary...
## $ pct_frpl <fct> 50-75%, 50-75%, 50-75%, 50-75%, 50-75%, 5
0-75%, 0-25%, 0-...
## $ exp <int> 17, 17, 17, 17, 17, 17, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10,
0, 10, 5, 5, 5, ...
## $ some_req <fct> Yes, Yes, Yes, No, Yes, Yes, No, No, No, No,
No, No, No, No, ...
## $ access <fct> Yes, Yes, Yes, No, Yes, Yes, No, No, No, No,
No, No, No, No, ...
## $ type_user <fct> User of 29 Programs, User of 29 Programs,
User of 29 Prog-
## $ accessN <dbl> 1, 1, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
1, 0, 1, 1, 1, ...
## $ featureid <fct> Adaptive, Create/Revise, Interactive, Parent,
## $ ses <fct> Med-low, Med-low, Med-low, Med-low, Med-
low, Med-low, High,
## $ ses2 <fct> Low, Low, Low, Low, Low, High, High,
## $ choiceN <dbl> 0, 0, 0, 1, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, ...
## $ choice <fct> No, No, No, Yes, No, No, Yes, Yes, Yes, Ye-
es, Yes, Yes, Ye...

data_wide_JH <- data_wide [,c("weight_state", "id",
"band", "pct_frpl", "exp",
"type_user",
"some_req_videos", "some_req_interactive", "some
_req_practice",
"some_req_adaptive","some_req_createrevise","som
_e_req_parent",
"use_any_videos","use_any_interactive","use_anyp
actice",
"use_any_adaptive","use_any_createrevise","use_an
y_parent")]


dplyr::rename(teacherid = id) %>%
dplyr::rename (gradeband = band) %>%
dplyr::mutate(ses = pct_frpl %>%
forcats::fct_recode("High" = "0-25\%", #High SES
"Med-high" = "25-50\%",
"Med-low" = "50-75\%",
"Low" = "75-100\%")) %>%

means Low %FRPL
dplyr::mutate(ses2 = pct_frpl %>%
forcats::fct_recode("High" = "0-25\%",
"High" = "25-50\%",
"Low" = "50-75\%",
"Low" = "75-100\%")) %>%

#dplyr::rename( starts_with("choice_") = starts_with("some_req_") ) %>%
dplyr::rename(access_videos = use_any_videos) %>%
dplyr::rename(access_interactive = use_any_interactive) %>%
dplyr::rename(access_practice = use_any_practice) %>%
dplyr::rename(access_adaptive = use_any_adaptive) %>%
dplyr::rename(access_createrevise = use_any_createrevise) %>%
dplyr::rename(access_parent = use_any_parent) %>%

#dplyr::rename( starts_with("choice_") = starts_with("some_req_") ) %>%
dplyr::filter(type_user != "Only Used Other Programs") %>%
dplyr::filter(type_user != "Broke Protocol") %>%
#dplyr::filter(!teacherid %in% c("T082791", "T120952", "T139821")) %>%
dplyr::filter(complete.cases(exp, ses))
data_wide_JH %>%
tibble::glimpse()

## Rows: 1,864
## Columns: 14
## $ weight_state        <fct> NM, Other, Other, Other, Other, Other, MS
## $ teacherid           <fct> T000298, T002113, T002750, T004144
## $ gradeband           <fct> Elementary, High School, Elementary, Elementary
## $ pct_frpl            <fct> 50-75\%, 0-25\%, 50-75\%, 0-25\%, 50-7
## $ exp                 <int> 17, 10, 5, 5, 7, 6, 18, 13, 12, 17
## $ type_user           <fct> User of 29 Programs, Non-user of A
## $ access_videos       <fct> Yes, No, Yes, Yes, Yes, Yes, Yes,
<table>
<thead>
<tr>
<th>Variable</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>access_interactive</td>
<td>Yes, No, Yes, No, Yes, Yes, No, Yes, No, Yes, Ye...</td>
</tr>
<tr>
<td>access_practice</td>
<td>Yes, No, Yes, Yes, Yes, Yes, Yes, Y...</td>
</tr>
<tr>
<td>access_adaptive</td>
<td>Yes, No, No, Yes, Yes, No, No, No, No...</td>
</tr>
<tr>
<td>access_createrevise</td>
<td>Yes, No, Yes, No, Yes, Yes, No, Ye...</td>
</tr>
<tr>
<td>access_parent</td>
<td>No, No, No, Yes, Yes, No, Yes, Yes, Yes, Ye...</td>
</tr>
<tr>
<td>ses</td>
<td>Med-low, High, Med-low, High, Med-low, Med-low, Me...</td>
</tr>
<tr>
<td>ses2</td>
<td>Low, High, Low, High, Low, Low, Hi...</td>
</tr>
</tbody>
</table>
Exploratory Data Analysis

Sample Size: Inclusion & Exclusion Criteria

Type of User:

```r
data_wide %>% #before filtering
  furniture::table1(type_user, 
    #splitby = ~ band, 
    total = TRUE, 
    na.rm = FALSE, 
    output = "markdown")
```

<table>
<thead>
<tr>
<th>type_user</th>
<th>Mean/Count (SD/%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broke Protocol</td>
<td>20 (1%)</td>
</tr>
<tr>
<td>Non-user of ALL Programs</td>
<td>223 (11%)</td>
</tr>
<tr>
<td>Only Used Other Programs</td>
<td>80 (3.9%)</td>
</tr>
<tr>
<td>User of 29 Programs</td>
<td>1704 (84.1%)</td>
</tr>
<tr>
<td>NA</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

Missing Values

```r
data_wide %>%
  dplyr::filter(type_user != "Only Used Other Programs") %>%
  dplyr::filter(type_user != "Broke Protocol") %>%
  dplyr::select(exp, pct_frpl) %>%
  is.na() %>%
  colSums()
```

<table>
<thead>
<tr>
<th>exp</th>
<th>pct_frpl</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>26</td>
</tr>
</tbody>
</table>

N = 2027 - 80 who only used “other” programs
- keep 3 who didn’t complete the “choice” endorsements
- 20 who broke protocol (i.e., didn’t finish the survey)
- 37 missing experience
- 26 missing ses

Final Sample:
N = 1,864 teachers X 6 features = 11,184 total lines
Descriptives

State
data_wide_JH %>%
  furniture::table1(weight_state,
    output = "markdown",
    total = TRUE)

<table>
<thead>
<tr>
<th>State</th>
<th>Mean/Count (SD/%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 1864</td>
</tr>
<tr>
<td>CA</td>
<td>125 (6.7%)</td>
</tr>
<tr>
<td>DE</td>
<td>116 (6.2%)</td>
</tr>
<tr>
<td>FL</td>
<td>115 (6.2%)</td>
</tr>
<tr>
<td>LA</td>
<td>114 (6.1%)</td>
</tr>
<tr>
<td>MA</td>
<td>118 (6.3%)</td>
</tr>
<tr>
<td>MS</td>
<td>106 (5.7%)</td>
</tr>
<tr>
<td>NE</td>
<td>118 (6.3%)</td>
</tr>
<tr>
<td>NM</td>
<td>127 (6.8%)</td>
</tr>
<tr>
<td>NY</td>
<td>111 (6%)</td>
</tr>
<tr>
<td>RI</td>
<td>116 (6.2%)</td>
</tr>
<tr>
<td>TN</td>
<td>126 (6.8%)</td>
</tr>
<tr>
<td>WI</td>
<td>106 (5.7%)</td>
</tr>
<tr>
<td>Other</td>
<td>466 (25%)</td>
</tr>
</tbody>
</table>

Grade Band
data_wide_JH %>%
  furniture::table1("Grade Band" = gradeband)

```r
# Grade Band Mean/Count (SD/%) n = 1864
# Elementary 1014 (54.4%) Middle School 458 (24.6%)
# High School 392 (21%)
```
Experience
data_wide_JH %>%
  dplyr::select(exp) %>%
  summary()

##       exp
##  Min.   : 1.00
##  1st Qu.: 8.00
##  Median :13.00
##  Mean   :14.45
##  3rd Qu.:20.00
##  Max.   :47.00
data_wide_JH %>%
  ggplot(aes(exp)) +
  geom_histogram(binwidth = 2,
                 color = "black",
                 alpha = .5) +
  #facet_wrap(~ gradeband, ncol = 1) +
  theme_bw() +
  labs(x = "Teacher's Experience, years",
       y = "Frequency Count")

ggsave(filename = "Teacher_Exp_histogram_9-30-22.png",
        width = 7,
Descriptive Statistics: Grade Band, SES, and Teacher Experience

The percentage of students in a school who qualify for free and reduced-priced

```r
data_wide_JH %>%
  furniture::table1("School SES" = ses,
                   "Teacher's Experience, yr" = exp,
                   splitby = ~ gradeband,
                   digits = 2,
                   total = TRUE,
                   test = TRUE,
                   na.rm = FALSE,
                   output = "markdown")
```

## The test is for the stratified data relationships.

<table>
<thead>
<tr>
<th>School SES</th>
<th>Total</th>
<th>Elementary</th>
<th>Middle School</th>
<th>High School</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 1864</td>
<td>n = 1014</td>
<td>n = 458</td>
<td>n = 392</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>428 (23%)</td>
<td>199 (19.6%)</td>
<td>110 (24%)</td>
<td>119 (30.4%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Med-high</td>
<td>664 (35.6%)</td>
<td>336 (33.1%)</td>
<td>164 (35.8%)</td>
<td>164 (41.8%)</td>
<td></td>
</tr>
<tr>
<td>Med-low</td>
<td>468 (25.1%)</td>
<td>271 (26.7%)</td>
<td>114 (24.9%)</td>
<td>83 (21.2%)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>304 (16.3%)</td>
<td>208 (20.5%)</td>
<td>70 (15.3%)</td>
<td>26 (6.6%)</td>
<td></td>
</tr>
<tr>
<td>NA</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Teacher’s Experience, yr</td>
<td>14.45 (8.33)</td>
<td>14.55 (8.21)</td>
<td>13.98 (8.20)</td>
<td>14.74 (8.33)</td>
<td>0.342</td>
</tr>
</tbody>
</table>
data_wide_JH %>%
  furniture::table1("Teacher Experience, yr" = exp,
  splitby = ~ ses,
  digits = 2,
  total = TRUE,
  test = TRUE,
  na.rm = FALSE,
  output = "markdown")

## The test is for the stratified data relationships.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>High</th>
<th>Med-high</th>
<th>Med-low</th>
<th>Low</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>1864</td>
<td>428</td>
<td>664</td>
<td>468</td>
<td>304</td>
<td>0.109</td>
</tr>
<tr>
<td>Teacher Experience, yr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(8.23)</td>
<td>(7.68)</td>
<td>(8.40)</td>
<td>(8.45)</td>
<td>(8.24)</td>
<td></td>
</tr>
</tbody>
</table>
Choice Problems: Justify Drop

Teachers were only asked about “choice” for programs they reported using. Therefore, over a third (3946/11174 = 35.34%) of my data were not given the “choice” question.

Choice variable is near-separable. Which is causing convergence issues.

Table 5

<table>
<thead>
<tr>
<th>Choice Variable Near-Separability</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>data_long_JH %&gt;%</td>
<td></td>
</tr>
<tr>
<td>group_by(access) %&gt;%</td>
<td></td>
</tr>
<tr>
<td>furniture::table1(choice,</td>
<td></td>
</tr>
<tr>
<td>output = &quot;markdown&quot;,</td>
<td></td>
</tr>
<tr>
<td>total = TRUE,</td>
<td></td>
</tr>
<tr>
<td>na.rm = FALSE)</td>
<td></td>
</tr>
</tbody>
</table>

## Using dplyr::group_by() groups: access

<table>
<thead>
<tr>
<th>Total</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 11184</td>
<td>n = 3954</td>
<td>n = 7230</td>
</tr>
<tr>
<td>choice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2061 (18.4%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Yes</td>
<td>9113 (81.5%)</td>
<td>3954 (100%)</td>
</tr>
<tr>
<td>NA</td>
<td>10 (0.1%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>
**Results for Research Question 1 Part 1**

**Table 3**

*Counts, Percents, and Predicted Probabilities of Teachers’ Access*

```r
furniture::table1(access_videos, access_interactive, access_practice, access_adaptive, access_createrevise, access_parent, 
                   total = TRUE, 
                   test = TRUE, 
                   na.rm = TRUE, 
                   digits = 2, 
                   output = "markdown")
```

<table>
<thead>
<tr>
<th>Access Type</th>
<th>Mean/Count (SD/%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>access_videos</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>497 (26.7%)</td>
</tr>
<tr>
<td>Yes</td>
<td>1367 (73.3%)</td>
</tr>
<tr>
<td>access_interactive</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>804 (43.1%)</td>
</tr>
<tr>
<td>Yes</td>
<td>1060 (56.9%)</td>
</tr>
<tr>
<td>access_practice</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>337 (18.1%)</td>
</tr>
<tr>
<td>Yes</td>
<td>1527 (81.9%)</td>
</tr>
<tr>
<td>access_adaptive</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>892 (47.9%)</td>
</tr>
<tr>
<td>Yes</td>
<td>972 (52.1%)</td>
</tr>
<tr>
<td>access_createrevise</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>628 (33.7%)</td>
</tr>
<tr>
<td>Yes</td>
<td>1236 (66.3%)</td>
</tr>
<tr>
<td>access_parent</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>796 (42.7%)</td>
</tr>
<tr>
<td>Yes</td>
<td>1068 (57.3%)</td>
</tr>
</tbody>
</table>
Figure 6

*Observed Percent of Feature Access*

data_long_3H %>%

dplyr::group_by(featureid) %>%

dplyr::summarise(N=n(),
    M=mean(accessN), #These are just proportions
    SD = sd(accessN),
    SE = SD/sqrt(N)) %>%

ggplot(aes(x = featureid,
    y = M,
    group=1)) +

  geom_point()+
  # geom_point(position = position_dodge(width = .01)) +
  geom_line()+
  #\ ylim(0, .9) +
  scale_x_discrete(name="Feature")+
  scale_y_continuous(name = "Observed Percent of Feature Access",
    limits = c(0,1),
    labels = scales::percent)+
  geom_errorbar(aes(ymin = M - 1.96*SE,
    ymax = M + 1.96*SE),
    width = .3) +

  theme_bw()
ggsave(`filename = "Percent_Access_Feature_9-29-22.png",`,
Demographic Summary Table: Access by Grade Band

data_wide_JH %>%
dplyr::group_by(gradeband) %>%
furniture::table1(access_videos, access_interactive, access_practice, access_adaptive, access_createrevise, access_parent, total = TRUE, #test = TRUE, na.rm = TRUE, digits = 2, output = "markdown")

## Using dplyr::group_by() groups: gradeband

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Elementary</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>access_videos</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>497 (26.7%)</td>
<td>198 (19.5%)</td>
<td>117 (25.5%)</td>
<td>182 (46.4%)</td>
</tr>
<tr>
<td>Yes</td>
<td>1367 (73.3%)</td>
<td>816 (80.5%)</td>
<td>341 (74.5%)</td>
<td>210 (53.6%)</td>
</tr>
<tr>
<td><strong>access_interactive</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>804 (43.1%)</td>
<td>341 (33.6%)</td>
<td>249 (54.4%)</td>
<td>214 (54.6%)</td>
</tr>
<tr>
<td>Yes</td>
<td>1060 (56.9%)</td>
<td>673 (66.4%)</td>
<td>209 (45.6%)</td>
<td>178 (45.4%)</td>
</tr>
<tr>
<td><strong>access_practice</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>337 (18.1%)</td>
<td>128 (12.6%)</td>
<td>71 (15.5%)</td>
<td>138 (35.2%)</td>
</tr>
<tr>
<td>Yes</td>
<td>1527 (81.9%)</td>
<td>886 (87.4%)</td>
<td>387 (84.5%)</td>
<td>254 (64.8%)</td>
</tr>
<tr>
<td><strong>access_adaptive</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>892 (47.9%)</td>
<td>314 (31%)</td>
<td>228 (49.8%)</td>
<td>350 (89.3%)</td>
</tr>
<tr>
<td>Yes</td>
<td>972 (52.1%)</td>
<td>700 (69%)</td>
<td>230 (50.2%)</td>
<td>42 (10.7%)</td>
</tr>
<tr>
<td><strong>access_createrevise</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>628 (33.7%)</td>
<td>344 (33.9%)</td>
<td>156 (34.1%)</td>
<td>128 (32.7%)</td>
</tr>
<tr>
<td>Yes</td>
<td>1236 (66.3%)</td>
<td>670 (66.1%)</td>
<td>302 (65.9%)</td>
<td>264 (67.3%)</td>
</tr>
<tr>
<td><strong>access_parent</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>796 (42.7%)</td>
<td>419 (41.3%)</td>
<td>163 (35.6%)</td>
<td>214 (54.6%)</td>
</tr>
<tr>
<td>Yes</td>
<td>1068 (57.3%)</td>
<td>595 (58.7%)</td>
<td>295 (64.4%)</td>
<td>178 (45.4%)</td>
</tr>
</tbody>
</table>
Observed Feature Access Visualizations

Figure 7

Observed Percent of Feature Access by Grade Band
data_long_JH %>%
  dplyr::group_by(featureid, gradeband) %>%
  dplyr::summarise(N = n(),
                  M = mean(accessN), # These are just proportions
                  SD = sd(accessN),
                  SE = SD/sqrt(N)) %>%
dplyr::ungroup() %>%
ggplot(aes(x = featureid,
             y = M,
             group = gradeband)) +
  geom_point(aes(shape = gradeband,
                 color = gradeband),
             size = 2,
             position = position_dodge(width = .25)) +
  geom_line(aes(linetype = gradeband,
                color = gradeband),
            position = position_dodge(width = .25)) +
  geom_errorbar(aes(ymin = M - 1.96*SE,
                    ymax = M + 1.96*SE,
                    color = gradeband),
               width = .25,
               position = position_dodge(width = .25)) +
labs(x = "Feature",
      shape = "Grade Band",
      linetype = "Grade Band",
      color = "Grade Band") +
  scale_y_continuous(name = "Observed Percent of Feature Access",
                      limits = c(0, 1),
                      labels = scales::percent) +
  theme_bw() +
  theme(legend.key.width = unit(1.8, "cm"),
        legend.key.height = unit(.45, "cm"),
        legend.background = element_rect(color = "black"),
        legend.position = c(0, 0),
        legend.justification = c(-0.1, -0.1)) +
  scale_linetype_manual(values = c("solid", "longdash", "dotdash"))
```r
ggsave(filename = "Percent_access_feature_byBand_9-29-22_color.png",
       height = 4,
       width = 6,
       units = "in")
```
```r
data_long_JH %>%
dplyr::group_by(featureid, ses) %>%
  dplyr::summarise(N = n(),
                  M = mean(accessN),  # These are just proportions
                  SD = sd(accessN),
                  SE = SD/sqrt(N)) %>%
dplyr::ungroup()
%>%
ggplot(aes(x = featureid,
           y = M,
           group = ses)) +
  geom_point(aes(shape = ses,
                  color = ses),
             size = 2,
             position = position_dodge(width = .25)) +
  geom_line(aes(linetype = ses,
                color = ses),
            position = position_dodge(width = .25)) +
  geom_errorbar(aes(ymin = M - 1.96*SE,
                    ymax = M + 1.96*SE,
                    color = ses),
              width = .25,
              position = position_dodge(width = .25)) +
  labs(x = "Feature",
       shape = "SES",
       linetype = "SES",
       color = "SES") +
  scale_y_continuous(name = "Observed Percent of Feature Access",
                     limits = c(0, 1),
                     labels = scales::percent) +
  theme_bw() +
  theme(legend.key.width = unit(1.8, "cm"),
        legend.key.height = unit(.45, "cm"),
        legend.background = element_rect(color = "black"),
        legend.position = c(0, 0),
        legend.justification = c(-0.1, -0.1) +
        scale_linetype_manual(values = c("solid", "longdash", "dotdash",
                                   "dotted")))
```

## `summarise()` has grouped output by 'featureid'. You can override using the
## `.groups` argument.
```r
ggsave(filename = "Percent_access_feature_bySES_9-30-22_color.png",
       height = 4,
       width = 6,
       units = "in")
```
data_long_JH %>%
dplyr::group_by(featureid, gradeband, ses) %>%

dplyr::summarise(N=n(),
  M=mean(accessN), #These are just proportions
  SD = sd(accessN),
  SE = SD/sqrt(N)) %>%
dplyr::ungroup() %>%
ggplot(aes(x=featureid,
  y=M,
  group = ses)) +
geom_point(aes(shape=ses,
    color=ses),
  position = position_dodge(.20)) +
facet_grid(rows = vars(gradeband)) +
geom_line(aes(linetype = ses,
    color = ses)) +
theme_bw() +
labs(y = "Observed Proportion of Feature Access") +
scale_y_continuous(labels = scales::percent)

## `summarise()` has grouped output by 'featureid', 'gradeband'.
You can override
## using the `.groups` argument.
Observed Feature Access by Grade Band and SES paneled by Feature

**Figure 8**

*Observed Percent Access to Feature by Grade Band and SES*

data_long_JH %>%
dplyr::group_by(featureid, gradeband, ses) %>%
dplyr::summarise(N=n(),
                  M=mean(accessN), #These are just proportions
                  SD = sd(accessN),
                  SE = SD/sqrt(N)) %>%
dplyr::ungroup() %>%
dplyr::mutate(ses =forcats::fct_rev(ses)) %>%
#dplyr::mutate(ses = ses %>%
#   forcats::fct_recode("Low" = "75-100%",
#   "Med-low" = "50-75%",
#   "Med-high" = "25-50%",
#   "High" = "0-25%")) %>% #H
high SES means Low %FRPL

dplyr::mutate(gradeband = gradeband %>%
              forcats::fct_recode("High\nSchool" = "High School",
                         "Middle\nSchool" = "Middle School",
                         "Elementary\nSchool")) %>%
ggplot(aes(x=gradeband,
           y=M,
           group = ses)) +
geom_point(aes(shape=ses),
           size = 1.5,
           position = position_dodge(.20)) +
facet_wrap(~ featureid) +
geom_line(aes(linetype = ses),
         position = position_dodge(.20)) +
theme_bw() +
labs(x = NULL,
y = "Observed Percent Access to Feature",
shape = "School SES (FRPL): ",
linetype = "School SES (FRPL): ") +
theme(legend.position = c(1.01, .53),
      legend.justification = c(1.1, -0.1),
      legend.background = element_rect(color = "black"),
legend.key.width = unit(1.4, "cm"),
legend.key.height = unit(.45,"cm") +
# scale_linetype_manual(values = c("solid", "longdash")) +
scale_y_continuous(limits = c(0,1),
                    labels = scales::percent)

## `summarise()` has grouped output by 'featureid', 'gradeband'.
## You can override
## using the `.groups` argument.
## Warning: Unknown levels in `f`: Elementary
## School

ggsave(filename = "Percent_access_featurepanel_bySESGradeband_10-15-22.png",
       width = 7,
       height = 5.5,
       units = "in")
Inferential Data Analysis

GLMM: Null Model

First Null Model

This first null model was calculated to compare with fit_full. Choice was included in fit_full and due to missing data in choice, three teacher had to be excluded from this model as well as form fit_full for comparison. Models can only be compared from the same exact dataset.

```r
fit_nullf <- lme4::glmer(accessN ~ featureid + (1|teacherid),
                          data = data_long_JH_f,
                          family = binomial(link="logit"),
                          )
```

Final Null Model

Once the decision was made to drop choice from the model, three teachers that were filtered from the data were added back in and a new null model was calculated.

```r
fit_null <- lme4::glmer(accessN ~ featureid + (1|teacherid),
                         data = data_long_JH,
                         family = binomial(link="logit"),
                         )
```

```r
summary(fit_null)
## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: binomial  ( logit )
## Formula: accessN ~ featureid + (1 | teacherid)
##    Data: data_long_JH
##
## ## AIC      BIC    logLik deviance df.resid
##  12106.0  12157.3 -6046.0  12092.0    11177
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.3138 -0.5004  0.2636  0.4933  1.9187
##
## Random effects:
## Groups   Name     Variance  Std.Dev.
## teacherid (Intercept) 3.301     1.817
## Number of obs: 11184, groups: teacherid, 1864
## Fixed effects:
```
## Estimate Std. Error z value Pr(>|z|)

|                                | Estimate | Std. Error | z value | Pr(>|z|) |
|--------------------------------|----------|------------|---------|---------|
| (Intercept)                    | 1.53493  | 0.08060    | 19.043  | < 2e-16 ** |
| featureidInteractive           | -1.15465 | 0.08931    | -12.929 | < 2e-16 ** |
| featureidPractice              | 0.77305  | 0.09997    | 7.733   | 1.05e-14 ** |
| featureidAdaptive              | -1.45588 | 0.08976    | -16.219 | < 2e-16 ** |
| featureidCreate/Revise         | -0.52341 | 0.08998    | -5.817  | 6.00e-09 ** |
| featureidParent                | -1.12698 | 0.08929    | -12.621 | < 2e-16 ** |

---

Signif. codes:  
  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Correlation of Fixed Effects:

<table>
<thead>
<tr>
<th></th>
<th>(Intr)</th>
<th>ftrdIn</th>
<th>ftrdPrc</th>
<th>ftrdAd</th>
<th>ftrdC/R</th>
</tr>
</thead>
<tbody>
<tr>
<td>ftrdIntrctv</td>
<td>-0.633</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ftrdPrcctc</td>
<td>-0.508</td>
<td>0.458</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ftrdAdptv</td>
<td>-0.641</td>
<td>0.571</td>
<td>0.451</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ftrdCrt/Rvs</td>
<td>-0.607</td>
<td>0.546</td>
<td>0.465</td>
<td>0.547</td>
<td></td>
</tr>
<tr>
<td>featuredPrnt</td>
<td>-0.632</td>
<td>0.566</td>
<td>0.459</td>
<td>0.571</td>
<td>0.546</td>
</tr>
</tbody>
</table>
Results for Research Question 1 Part 2

```r
fit_null %>%
  emmeans::emmeans(pairwise ~ featureid, type = "response") # gives proportions instead of logit scale
```

## $emmeans

<table>
<thead>
<tr>
<th>featureid</th>
<th>prob</th>
<th>SE</th>
<th>df asymp.LCL</th>
<th>asymp.UCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Videos</td>
<td>0.823</td>
<td>0.0118 Inf</td>
<td>0.799</td>
<td>0.845</td>
</tr>
<tr>
<td>Interactive</td>
<td>0.594</td>
<td>0.0176 Inf</td>
<td>0.559</td>
<td>0.628</td>
</tr>
<tr>
<td>Practice</td>
<td>0.910</td>
<td>0.0075 Inf</td>
<td>0.894</td>
<td>0.923</td>
</tr>
<tr>
<td>Adaptive</td>
<td>0.520</td>
<td>0.0181 Inf</td>
<td>0.484</td>
<td>0.555</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>0.733</td>
<td>0.0149 Inf</td>
<td>0.703</td>
<td>0.761</td>
</tr>
<tr>
<td>Parent</td>
<td>0.601</td>
<td>0.0176 Inf</td>
<td>0.566</td>
<td>0.634</td>
</tr>
</tbody>
</table>

## Confidence level used: 0.95

## Intervals are back-transformed from the logit scale

## $contrasts

<table>
<thead>
<tr>
<th>contrast</th>
<th>odds.ratio</th>
<th>SE</th>
<th>df null z.ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Videos / Interactive</td>
<td>3.173</td>
<td>0.2834 Inf</td>
<td>1 12.929 &lt; .0001</td>
</tr>
<tr>
<td>Videos / Practice</td>
<td>0.462</td>
<td>0.0461 Inf</td>
<td>1 -7.733 &lt; .0001</td>
</tr>
<tr>
<td>Videos / Adaptive</td>
<td>4.288</td>
<td>0.3849 Inf</td>
<td>1 16.219 &lt; .0001</td>
</tr>
<tr>
<td>Videos / (Create/Revise)</td>
<td>1.688</td>
<td>0.1519 Inf</td>
<td>1 5.817 &lt; .0001</td>
</tr>
<tr>
<td>Videos / Parent</td>
<td>3.086</td>
<td>0.2756 Inf</td>
<td>1 12.621 &lt; .0001</td>
</tr>
<tr>
<td>Interactive / Practice</td>
<td>0.145</td>
<td>0.0144 Inf</td>
<td>1 -19.480 &lt; .0001</td>
</tr>
<tr>
<td>Interactive / Adaptive</td>
<td>1.352</td>
<td>0.1120 Inf</td>
<td>1 3.634 0.0038</td>
</tr>
<tr>
<td>Interactive / (Create/Revise)</td>
<td>0.532</td>
<td>0.0454 Inf</td>
<td>1 -7.390 &lt; .0001</td>
</tr>
<tr>
<td>Interactive / Parent</td>
<td>0.973</td>
<td>0.0809 Inf</td>
<td>1 -0.333 0.9995</td>
</tr>
<tr>
<td>Practice / Adaptive</td>
<td>9.290</td>
<td>0.9271 Inf</td>
<td>1 22.334 &lt; .0001</td>
</tr>
<tr>
<td>Practice / (Create/Revise)</td>
<td>3.656</td>
<td>0.3605 Inf</td>
<td>1 13.150 &lt; .0001</td>
</tr>
<tr>
<td>Practice / Parent</td>
<td>6.686</td>
<td>0.6612 Inf</td>
<td>1 19.212 &lt; .0001</td>
</tr>
<tr>
<td>Adaptive / (Create/Revise)</td>
<td>0.394</td>
<td>0.0337 Inf</td>
<td>1 -10.524 &lt; .0001</td>
</tr>
</tbody>
</table>
225

## P value adjustment: tukey method for comparing a family of 6 estimates
## Tests are performed on the log odds ratio scale
GLMM: Main Effects

Full Model

Standardize Experience for Convergence
data_long_JH_f %>% # need to use only one line per teacher for accurate mean
dplyr::group_by(teacherid) %>%
dplyr::slice(1) %>%
dplyr::ungroup() %>%
dplyr::summarise(M = mean(exp, na.rm = TRUE),
                  SD = sd(exp, na.rm = TRUE))

### A tibble: 1 × 2
###   M  SD
###  <dbl> <dbl>
### 1  14.4  8.23

Fit Full

This would not converge until I found the right optimizer.

start_time <- Sys.time()
fit_full <- lme4::glmer(accessN ~ featureid +
                        ses2 +
                        gradeband +
                        I((exp - 14.44546)/8.226815) +
                        choice +
                        (1|teacherid),
                        data = data_long_JH_f,
                        control = glmerControl(optimizer = "bobyqa"),
                        family = binomial(link = "logit"))
end_time <- Sys.time()
end_time - start_time

#1.4 mins

allFit() to Run Multiple Optimizers

Next, I used allfit to test several optimizers in one shot: https://joshua-nugent.github.io/allFit/ Then, I came back and use the one it found works. Yay!

diff_optims_full <- allFit(fit_full, maxfun = 1e5)
diff_optims_OK_full <- diff_optims_full[sapply(diff_optims_full, is, "merMod")]

lapply(diff_optims_OK_full, function(x) x@optinfo$convc$message)

Rerun fit_full with optimizer “bobyqa”

summary(fit_full)
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
## Family: binomial ( logit )
## Formula:
## accessN ~ featureid + ses2 + gradeband + I((exp - 14.44546)/8.226815) +
##     choice + (1 | teacherid)
## Data: data_long_JH_f
## Control: glmerControl(optimizer = "bobyqa")
##
## AIC      BIC   logLik deviance df.resid
##  10342.8  10430.6 -5159.4  10318.8    11154
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.1938 -0.4328  0.0000  0.4800  2.3598
##
## Random effects:
## Groups    Name        Variance Std.Dev.
## teacherid (Intercept) 3.106    1.763
## Number of obs: 11166, groups:  teacherid, 1861
##
## Fixed effects:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept) 22.07558   11.70929   1.885   0.0594 .
## featureidInteractive e-16 -1.40093    0.09805 -14.287  < 2e-16 ***
## featureidPractice  e-10   0.65188    0.10601   6.149 7.80e-10 ***
## featureidAdaptive  e-16 -1.87627    0.10069  18.634  < 2e-16 ***
## featureidCreate/Revise  e-07 -0.48406    0.09527  -5.081 3.76
## featureidParent  e-16 -1.04288    0.09547  -10.924  < 2e-16 ***
## ses2Low         0.09675    0.10693   0.905  0.3656
## gradeband

Middle School

-0.24439 0.12607 -1.938 0.0526

High School

-1.04486 0.13123 -7.962 1.69e-15 ***

I((exp - 14.44546)/8.226815) -0.11982 0.05176 -2.315 0.0206 *

choiceYes -20.69517 11.70931 -1.767 0.0772 .

---

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Correlation of Fixed Effects:

(Intercept) ftrdIn ftrdPrc ftrdAd ftrC/R ftrdPrn ses2Lw grdbMS grdbHS

ftrdIntrctv -0.002

featrdPrctc -0.002 0.437

featrdAdptv -0.002 0.550 0.419

ftrdCrt/Rvs -0.002 0.531 0.463 0.519

featurdPrnt -0.002 0.551 0.454 0.550 0.538

ses2Low -0.002 -0.004 0.006 -0.005 0.001 -0.015

grdbndMddlS -0.002 0.003 -0.004 0.010 0.007 0.018 0.072

grdbndHghSc -0.002 0.037 -0.023 0.049 0.018 0.056 0.147 0.330

I((-14.4454)) 0.000 0.015 -0.007 0.015 0.005 0.014 0.047 0.032 0.010

choiceYes -1.000 -0.002 -0.002 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002

I((-14))

ftrdIntrctv

featrdPrctc

featrdAdptv

ftrdCrt/Rvs

featurdPrnt

ses2Low

grdbndMddlS

grdbndHghSc

I((-14.4454)

choiceYes 0.000
`Compare Full to Null`  
anova(fit_nullf, fit_full)  

```r  
# Data: data_long_JH_f  
# Models:  
# fit_nullf: accessN ~ featureid + (1 | teacherid)  
# fit_full: accessN ~ featureid + ses2 + gradeband + I((exp - 14 .44546)/8.226815) + choice + (1 | teacherid)  
# npar   AIC   BIC  logLik deviance  Chisq Df Pr(>Chisq)  
# fit_nullf    7 12080 12132 -6033.2 12066  
# fit_full    12 10343 10431 -5159.4 10319 1747.7 5 < 2.2e-16 ***  
```

`---`  
`## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1`

These run easily now, but only once we collapsed SES to two levels instead of 4. The other times these were run choice was going haywire and even the full model was struggling to converge with any accuracy.
Linearity Testing

probabilities <- predict(fit_full, type = "response")

num_data <- data_long_JH_f %>%
  dplyr::select(exp)
predictors <- colnames(num_data)

num_data <- num_data %>%
  mutate(logit = log(probabilities / (1 - probabilities))) %>%
  gather(key = "predictors", value = "predictor.value", -logit)

Error! Reference source not found.

ggplot(num_data, aes(logit, predictor.value)) +
  geom_point(size = 0.5, alpha = 0.5) +
  geom_smooth(method = "loess") +
  theme_bw() +
  facet_wrap(~predictors, scales = "free_y")

## `geom_smooth()` using formula 'y ~ x'

ggsave(filename = "Linearity of Experiences and Logit 10-27-22.png",
       width = 7,
       height = 4,
       units = "in")
## `geom_smooth()` using formula 'y ~ x'

### VIF Values

Error! Reference source not found.

vif(fit_full)

<table>
<thead>
<tr>
<th></th>
<th>GVIF</th>
<th>Df</th>
<th>GVIF^(1/(2*Df))</th>
</tr>
</thead>
<tbody>
<tr>
<td>featureid</td>
<td>1.00969</td>
<td>5</td>
<td>1.000965</td>
</tr>
<tr>
<td>ses2</td>
<td>1.02624</td>
<td>1</td>
<td>1.0130</td>
</tr>
<tr>
<td>gradeband</td>
<td>1.03246</td>
<td>2</td>
<td>1.0081</td>
</tr>
<tr>
<td>I((exp - 14.44546)/8.226815)</td>
<td>1.00379</td>
<td>1</td>
<td>1.0019</td>
</tr>
<tr>
<td>choice</td>
<td>1.00002</td>
<td>1</td>
<td>1.000010</td>
</tr>
</tbody>
</table>
First “Fit Dropchoice” for Comparison with Full

Also did not converge at first. Tried the same optimizer that worked for Full Model, which worked.

Calculate Fit Drop Choice with same dataset as Fit Full for comparison.

```r
start_time <- Sys.time()
fit_dropchoicef <- lme4::glmer(accessN ~ featureid +
                               ses2 +
                               gradeband +
                               I((exp - 14.44546)/8.226815) +
                               choice +
                               (1|teacherid),
                               data = data_long_JH_f,
                               control = glmerControl(optimizer = "bobyqa"),
                               family = binomial(link = "logit"),
                           )
end_time <- Sys.time()
end_time - start_time

#40 secs
```

Compare with Fit Full

```r
anova(fit_dropchoicef, fit_full)
```

```
## Data: data_long_JH_f
## Models:
## fit_dropchoicef: accessN ~ featureid + ses2 + gradeband + I((exp - 14.44546)/8.226815) + (1 | teacherid)
## fit_full: accessN ~ featureid + ses2 + gradeband + I((exp - 14.44546)/8.226815) + choice + (1 | teacherid)
##                 npar   AIC   BIC  logLik deviance Chisq Df Pr(>Chisq)
## fit_dropchoicef   11 11898 11978 -5937.9    11876
## fit_full          12 10343 10431 -5159.4    10319  1557  1 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```
Final Fit Drop Choice

Re-standardize Teacher Experience

Dropping choice meant that I could add three teachers back in who were only missing data for the choice variable. Therefore, the mean and standard deviation need to be recalculated.

data_long_JH %>% # need to use only one line per teacher for accurate mean
dplyr::group_by(teacherid) %>%
dplyr::slice(1) %>%
dplyr::ungroup() %>%
dplyr::summarise(M = mean(exp, na.rm = TRUE),
                  SD = sd(exp, na.rm = TRUE))

## # A tibble: 1 × 2
##    M    SD
##  <dbl> <dbl>
## 1 14.4  8.23

start_time <- Sys.time()
fit_dropchoice <- lme4::glmer(accessN ~ featureid + ses2 + gradeband +
                              I((exp - 14.44903)/8.2345)^24) +
                              # choice +
                              (1|teacherid),
data = data_long_JH,
control = glmerControl(optimizer = "bobyqa"),
family = binomial(link = "logit")

end_time <- Sys.time()
end_time - start_time
# 43 secs

save(fit_dropchoice,
     file = "fit_glmer_dropchoice_main_10-24-22.RData")

summary(fit_dropchoice)

## Generalized linear mixed model fit by maximum likelihood
##   [Laplace Approximation] [glmerMod]
## Formula: accessN ~ featureid +
##                  ses2 + gradeband +
##                  I((exp - 14.44903)/8.2345)^24 +
##                  (1|teacherid),
##     data = data_long_JH,
##     control = glmerControl(optimizer = "bobyqa"),
##     family = binomial(link = "logit")
accessN ~ featureid + ses2 + gradeband + I((exp - 14.44903)/8.234524) + (1 | teacherid)

Data: data_long_JH
Control: glmerControl(optimizer = "bobyqa")

AIC      BIC   logLik deviance df.resid
11923.8  12004.3 -5950.9  11901.8    11173

Scaled residuals:
Min      1Q  Median      3Q     Max
-4.5030 -0.5219  0.2822  0.5123  1.9491

Random effects:
Groups   Name        Variance Std.Dev.
teacherid (Intercept) 2.894    1.701
Number of obs: 11184, groups: teacherid, 1864

Fixed effects:
(Intercept)           1.88794    0.10368  18.209 < 2e-16 ***
featureidInteractive -1.15549    0.08933 -12.935 < 2e-16 ***
featureidPractice    0.77161    0.09985   7.728 1.10e-14 ***
featureidAdaptive   -1.45677    0.08979 -16.225 < 2e-16 ***
featureidCreate/Revise -0.52375    0.09000 -5.819 5.92e-09 ***
featureidParent     -1.12780    0.08932 -12.627 < 2e-16 ***
eses2Low            0.25690    0.09921   2.590 0.0099 608 **
gradebandMiddle School -0.51763    0.11741 -4.409 1.04e-05 ***
gradebandHigh School -1.55745    0.12501 -12.458 < 2e-16 ***
I((exp - 14.44903)/8.234524) -0.16326    0.04813 -3.392 0.000694 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
(Intr) ftrdIn ftrdPrc ftrdAd ftrC/R ftrdPrn ses2Lw
```
grdbMS grdbHS
## ftrdIntrct -0.506
## featrdPrctc -0.386  0.458
## featrdAdptv -0.515  0.572  0.451
## ftrdCrt/Rvs -0.478  0.546  0.466  0.547
## featurdfPrnt -0.505  0.566  0.459  0.571  0.546
## ses2Low -0.437 -0.009  0.006 -0.012 -0.004 -0.009
## grdbndMddlS -0.407  0.017 -0.011  0.021  0.008  0.016  0.064
## grdbndHghSc -0.452  0.048 -0.031  0.059  0.022  0.047  0.142 0.320
## I((-14.44903/8.234524) -0.16 (0.05) ***
0.037  0.013
```
texreg::knitreg(list(fit_dropchoice),
   single.row = TRUE)

```
<table>
<thead>
<tr>
<th>Model 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
</tr>
<tr>
<td>featureidInteractive</td>
</tr>
<tr>
<td>featureidPractice</td>
</tr>
<tr>
<td>featureidAdaptive</td>
</tr>
<tr>
<td>featureidCreate/Revise</td>
</tr>
<tr>
<td>featureidParent</td>
</tr>
<tr>
<td>ses2Low</td>
</tr>
<tr>
<td>gradebandMiddle School</td>
</tr>
<tr>
<td>gradebandHigh School</td>
</tr>
<tr>
<td>(exp - 14.44903)/8.234524</td>
</tr>
<tr>
<td>AIC</td>
</tr>
<tr>
<td>BIC</td>
</tr>
<tr>
<td>Log Likelihood</td>
</tr>
<tr>
<td>Num. obs.</td>
</tr>
<tr>
<td>Num. groups: teacherid</td>
</tr>
<tr>
<td>Var: teacherid (Intercept)</td>
</tr>
</tbody>
</table>
```
Compare to Null Model

```r
anova(fit_null, fit_dropchoice)

## Data: data_long_JH
## Models:
## fit_null: accessN ~ featureid + (1 | teacherid)
## fit_dropchoice: accessN ~ featureid + ses2 + gradeband + I((exp - 14.44903)/8.234524) + (1 | teacherid)
##                npar   AIC   BIC  logLik deviance  Chisq Df Pr(Chisq)
## fit_null          7 12106 12157  -6046.0 12092
## fit_dropchoice   11 11924 12004  -5950.9 11902 190.23  4 < 2.2e-16 ***
##                ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```
GLMM: 2-way Interaction

Fit int

From here on out I used the “bobyqa” optimizer at the first attempt.

```r
start_time <- Sys.time()
fit_int <- lme4::glmer(accessN ~ featureid*gradeband +
                       ses2 +
                       I((exp - 14.44903)/8.234524) +
                       #choice +
                       (1|teacherid),
                       data = data_long_JH,
                       control = glmerControl(optimizer = "bobyqa")

end_time <- Sys.time()
end_time - start_time
#3.4 mins
#3.1

summary(fit_int)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula:
## accessN ~ featureid * gradeband + ses2 + I((exp - 14.44903)/8.234524) +
##               (1 | teacherid)
## Data: data_long_JH
## Control: glmerControl(optimizer = "bobyqa")
##
##  AIC   BIC  logLik deviance df.resid
## 11482.4 11636.1 -5720.2  11440.4    11163
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -5.6750 -0.4586  0.2684  0.4757  4.8393
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  teacherid (Intercept) 3.386    1.84
##
## Number of obs: 11184, groups: teacherid, 1864
##
## Fixed effects:
```
## Estimate Std. Err
ror z value
(Intercept) 2.02172 0.12
764  15.839
featureidInteractive -1.12274 0.12
874  -8.721
featureidPractice  0.76960 0.15
082   5.103
featureidAdaptive -0.93439 0.12
941  -7.220
featureidCreate/Revise -1.14325 0.12
869  -8.884
featureidParent -1.63667 0.12
820 -12.766
gradebandMiddle School -0.48294 0.20
097  -2.403
gradebandHigh School -1.91654 0.20
061  -9.553
ses2Low 0.27747 0.10
608   2.616
I((exp - 14.44903)/8.234524) -0.17537 0.05
149  -3.406
featureidInteractive:gradebandMiddle School -0.90050 0.22
484  -4.005
featureidPractice:gradebandMiddle School  0.24255 0.26
189   0.926
featureidAdaptive:gradebandMiddle School -0.79118 0.22
456  -3.523
featureidCreate/Revise:gradebandMiddle School  0.47829 0.22
590   2.117
featureidParent:gradebandMiddle School  0.86208 0.22
479   3.835
featureidInteractive:gradebandHigh School  0.59201 0.22
326   2.652
featureidPractice:gradebandHigh School -0.00688 0.24
051  -0.029
featureidAdaptive:gradebandHigh School -2.44735 0.26
956  -9.079
featureidCreate/Revise:gradebandHigh School  2.09221 0.23
021   9.088
featureidParent:gradebandHigh School 1.10593 0.22
279   4.964
Pr(>|z|)
(Intercept) < 2e-16 ***
featureidInteractive < 2e-16 ***
featureidPractice 3.35e-07 ***
## featureidAdaptive                             5.18e-13 ***
## featureidCreate/Revise                         < 2e-16 ***
## featureidParent                                < 2e-16 ***
## gradebandMiddle School                        0.016260 *
## gradebandHigh School                          < 2e-16 ***
## ses2Low                                       0.008908 **
## I((exp - 14.44903)/8.234524)                  0.000660 ***
## featureidInteractive:gradebandMiddle School   6.20e-05 ***
## featureidPractice:gradebandMiddle School      0.354370
## featureidAdaptive:gradebandMiddle School      0.000426 ***
## featureidCreate/Revise:gradebandMiddle School 0.034234 *
## featureidParent:gradebandMiddle School        0.000126 ***
## featureidInteractive:gradebandHigh School     0.008010 **
## featureidPractice:gradebandHigh School        0.977180
## featureidAdaptive:gradebandHigh School         < 2e-16 ***
## featureidCreate/Revise:gradebandHigh School    < 2e-16 ***
## featureidParent:gradebandHigh School          6.91e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation matrix not shown by default, as p = 20 > 12.
## Use print(x, correlation=TRUE) or
## vcov(x) if you need it
texreg::knitreg(fit_int,  
    single.row = TRUE)

<table>
<thead>
<tr>
<th>Model 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>2.02 (0.13) ***</td>
</tr>
<tr>
<td>featureidInteractive</td>
<td>-1.12 (0.13) ***</td>
</tr>
<tr>
<td>featureidPractice</td>
<td>0.77 (0.15) ***</td>
</tr>
<tr>
<td>featureidAdaptive</td>
<td>-0.93 (0.13) ***</td>
</tr>
<tr>
<td>featureidCreate/Revise</td>
<td>-1.14 (0.13) ***</td>
</tr>
<tr>
<td>featureidParent</td>
<td>-1.64 (0.13) ***</td>
</tr>
<tr>
<td>gradebandMiddle School</td>
<td>-0.48 (0.20) *</td>
</tr>
<tr>
<td>gradebandHigh School</td>
<td>-1.92 (0.20) ***</td>
</tr>
<tr>
<td>ses2Low</td>
<td>0.28 (0.11) **</td>
</tr>
<tr>
<td>(exp - 14.44903)/8.234524</td>
<td>-0.18 (0.05) ***</td>
</tr>
<tr>
<td>featureidInteractive:gradebandMiddle School</td>
<td>-0.90 (0.22) ***</td>
</tr>
<tr>
<td>featureidPractice:gradebandMiddle School</td>
<td>0.24 (0.26)</td>
</tr>
<tr>
<td>featureidAdaptive:gradebandMiddle School</td>
<td>-0.79 (0.22) ***</td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandMiddle School</td>
<td>0.48 (0.23) *</td>
</tr>
<tr>
<td>featureidParent:gradebandMiddle School</td>
<td>0.86 (0.22) ***</td>
</tr>
<tr>
<td>featureidInteractive:gradebandHigh School</td>
<td>0.59 (0.22) **</td>
</tr>
<tr>
<td>featureidPractice:gradebandHigh School</td>
<td>-0.01 (0.24)</td>
</tr>
<tr>
<td>featureidAdaptive:gradebandHigh School</td>
<td>-2.45 (0.27) ***</td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandHigh School</td>
<td>2.09 (0.23) ***</td>
</tr>
<tr>
<td>featureidParent:gradebandHigh School</td>
<td>1.11 (0.22) ***</td>
</tr>
<tr>
<td>AIC</td>
<td>11482.37</td>
</tr>
<tr>
<td>BIC</td>
<td>11636.13</td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>-5720.18</td>
</tr>
<tr>
<td>Num. obs.</td>
<td>11184</td>
</tr>
<tr>
<td>Num. groups: teacherid</td>
<td>1864</td>
</tr>
<tr>
<td>Var: teacherid (Intercept)</td>
<td>3.39</td>
</tr>
</tbody>
</table>

**Compare Fit int**

anova(fit_dropchoice, fit_int)

## Data: data_long_JH
## Models:
## fit_dropchoice: accessN ~ featureid + ses2 + gradeband + I((exp - 14.44903)/8.234524) + (1 | teacherid)
## fit_int: accessN ~ featureid * gradeband + ses2 + I((exp - 14.44903)/8.234524) + (1 | teacherid)

<table>
<thead>
<tr>
<th>npar</th>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>deviance</th>
<th>Chisq</th>
<th>Df</th>
<th>Pr(&gt;Chisq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>11924</td>
<td>12004</td>
<td>-5950.9</td>
<td>11902</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>11482</td>
<td>11636</td>
<td>-5720.2</td>
<td>11440</td>
<td>461.43</td>
<td>10</td>
<td>&lt; 2.2e-16</td>
</tr>
</tbody>
</table>

---

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
GLMM: 3-way Interaction

Fit int3

```r
start_time <- Sys.time()
fit_int3 <- lme4::glmer(accessN ~ featureid*gradeband*ses2 +
                      I((exp - 14.44903)/8.234524) +
                      #choice +
                      (1|teacherid),
                      data = data_long_JH,
                      control = glmerControl(optimizer = "bobyqa")
                      ,
                      family = binomial(link = "logit"))
end_time <- Sys.time()
end_time - start_time
#27.9 mins
#14.4 bobyqa
#16.9

save(fit_int3,
     file = "fit_glmer_int3_main_10-15-22.RData") #19 mins

summary(fit_int3)
```
<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>2.11517</td>
<td>0.158753</td>
</tr>
<tr>
<td>featureidInteractive</td>
<td>-1.20339</td>
<td>0.174042</td>
</tr>
<tr>
<td>featureidPractice</td>
<td>0.70067</td>
<td>0.202780</td>
</tr>
<tr>
<td>featureidAdaptive</td>
<td>-0.80173</td>
<td>0.176262</td>
</tr>
<tr>
<td>featureidCreate/Revise</td>
<td>-1.12800</td>
<td>0.174338</td>
</tr>
<tr>
<td>featureidParent</td>
<td>-1.47286</td>
<td>0.173384</td>
</tr>
<tr>
<td>gradebandMiddle School</td>
<td>-0.92229</td>
<td>0.256551</td>
</tr>
<tr>
<td>gradebandHigh School</td>
<td>-1.94332</td>
<td>0.247142</td>
</tr>
<tr>
<td>ses2Low</td>
<td>0.07851</td>
<td>0.231381</td>
</tr>
<tr>
<td>I((exp - 14.44903)/8.234524)</td>
<td>-0.17618</td>
<td>0.051502</td>
</tr>
<tr>
<td>featureidInteractive:gradebandMiddle School</td>
<td>-0.56584</td>
<td>0.288331</td>
</tr>
<tr>
<td>featureidPractice:gradebandMiddle School</td>
<td>0.42692</td>
<td>0.329488</td>
</tr>
<tr>
<td>featureidAdaptive:gradebandMiddle School</td>
<td>-1.11444</td>
<td>0.290871</td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandMiddle School</td>
<td>0.57874</td>
<td>0.288164</td>
</tr>
<tr>
<td>featureidParent:gradebandMiddle School</td>
<td>0.70187</td>
<td>0.286564</td>
</tr>
<tr>
<td>featureidInteractive:gradebandHigh School</td>
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<td>0.276642</td>
</tr>
<tr>
<td>featureidPractice:gradebandHigh School</td>
<td>-0.00997</td>
<td>0.298734</td>
</tr>
<tr>
<td>featureidAdaptive:gradebandHigh School</td>
<td>-2.74589</td>
<td>0.338543</td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandHigh School</td>
<td>2.04672</td>
<td>0.283190</td>
</tr>
<tr>
<td>featureidParent:gradebandHigh School</td>
<td>1.03517</td>
<td>0.275997</td>
</tr>
<tr>
<td>featureidInteractive:ses2Low</td>
<td>0.17689</td>
<td>0.257489</td>
</tr>
<tr>
<td>featureidPractice:ses2Low</td>
<td>0.15280</td>
<td>0.302660</td>
</tr>
</tbody>
</table>
## featureidAdaptive:ses2Low -0.28530
5  0.258890
## featureidCreate/Revise:ses2Low -0.03368
2  0.257111
## featureidParent:ses2Low -0.35280
0  0.255001
## gradebandMiddle School:ses2Low 1.15096
8  0.420843
## gradebandHigh School:ses2Low -0.03784
1  0.426806
## featureidInteractive:gradebandMiddle School:ses2Low -0.89033
1  0.467379
## featureidPractice:gradebandMiddle School:ses2Low -0.49193
6  0.554276
## featureidAdaptive:gradebandMiddle School:ses2Low 0.68288
5  0.469638
## featureidCreate/Revise:gradebandMiddle School:ses2Low -0.32669
2  0.472801
## featureidParent:gradebandMiddle School:ses2Low 0.30247
9  0.472178
## featureidInteractive:gradebandHigh School:ses2Low -0.17819
9  0.481095
## featureidPractice:gradebandHigh School:ses2Low 0.11328
9  0.520187
## featureidAdaptive:gradebandHigh School:ses2Low 0.81009
2  0.565597
## featureidCreate/Revise:gradebandHigh School:ses2Low 0.14229
2  0.497780
## featureidParent:gradebandHigh School:ses2Low 0.02412
3  0.480283
## z value
Pr(>|z|)
## (Intercept) 13.324 < 2e-16 ***
## featureidInteractive -6.914 4.70e-12 ***
## featureidPractice 3.455 0.000550 ***
## featureidAdaptive -4.549 5.40e-06 ***
## featureidCreate/Revise -6.470 9.78e-11 ***
## featureidParent -8.495 < 2e-16 ***
## gradebandMiddle School -3.595 0.000324 ***
## gradebandHigh School
-7.863

## gradebandMiddle School

### featureidInteractive:gradebandMiddle School
-1.962

### featureidPractice:gradebandMiddle School
1.296

### featureidAdaptive:gradebandMiddle School
-3.821

### featureidCreate/Revise:gradebandMiddle School
2.008

### featureidParent:gradebandMiddle School
2.449

## gradebandHigh School

### featureidInteractive:gradebandHigh School
2.434

### featureidPractice:gradebandHigh School
-0.033

### featureidAdaptive:gradebandHigh School
-8.111

### featureidCreate/Revise:gradebandHigh School
7.227

### featureidParent:gradebandHigh School
3.751

## ses2Low

### featureidInteractive:ses2Low
0.687

### featureidPractice:ses2Low
0.505

### featureidAdaptive:ses2Low
-1.102

### featureidCreate/Revise:ses2Low
-0.131

### featureidParent:ses2Low
-1.384

## gradebandMiddle School:ses2Low

### featureidInteractive:gradebandMiddle School:ses2Low
-1.905

### featureidPractice:gradebandMiddle School:ses2Low
-0.888

### featureidAdaptive:gradebandMiddle School:ses2Low
1.454
## featureidCreate/Revise:gradebandMiddle School:ses2Low -0.691  
0.489583  
## featureidParent:gradebandMiddle School:ses2Low 0.641  
0.521779  
## featureidInteractive:gradebandHigh School:ses2Low -0.370  
0.711082  
## featureidPractice:gradebandHigh School:ses2Low 0.218  
0.827596  
## featureidAdaptive:gradebandHigh School:ses2Low 1.432  
0.152064  
## featureidCreate/Revise:gradebandHigh School:ses2Low 0.286  
0.774991  
## featureidParent:gradebandHigh School:ses2Low 0.050  
0.959941  
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
## Correlation matrix not shown by default, as p = 37 > 12.  
## Use print(x, correlation=TRUE) or  
## vcov(x) if you need it  
## optimizer (bobyqa) convergence code: 0 (OK)  
## maxfun < 10 * length(par)^2 is not recommended.
library(sjstats)

# Fit models
fit_int <- lme4::lmer(accessN ~ featureid * gradeband + ses2 + I((exp - 14.44903)/8.234524) + (1 | teacherid), data_long_JH)
fit_int3 <- lme4::lmer(accessN ~ featureid * gradeband * ses2 + I((exp - 14.44903)/8.234524) + (1 | teacherid), data_long_JH)

# Compare models
anova(fit_int, fit_int3)

## Data: data_long_JH
## Models:
## fit_int: accessN ~ featureid * gradeband + ses2 + I((exp - 14.44903)/8.234524) + (1 | teacherid)
## fit_int3: accessN ~ featureid * gradeband * ses2 + I((exp - 14.44903)/8.234524) + (1 | teacherid)

## npar   AIC   BIC  logLik deviance  Chisq Df Pr(>Chisq)
## fit_int    21 11482 11636 -5720.2    11440
## fit_int3   38 11475 11754 -5699.6    11399 4 1.099 17  0.000903 ***
##          npar   AIC   BIC  logLik deviance  Chisq Df Pr(>Chisq)
## fit_int    21 11482 11636 -5720.2    11440
## fit_int3   38 11475 11754 -5699.6    11399 4 1.099 17  0.000903 ***

## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

texreg::knitreg(list(fit_int,fit_int3),
  single.row = TRUE)

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>2.02 (0.13)***</td>
<td>2.12 (0.16)***</td>
</tr>
<tr>
<td>featureidInteractive</td>
<td>-1.12 (0.13)***</td>
<td>-1.20 (0.17)***</td>
</tr>
<tr>
<td>featureidPractice</td>
<td>0.77 (0.15)***</td>
<td>0.70 (0.20)***</td>
</tr>
<tr>
<td>featureidAdaptive</td>
<td>-0.93 (0.13)***</td>
<td>-0.80 (0.18)***</td>
</tr>
<tr>
<td>featureidCreate/Revise</td>
<td>-1.14 (0.13)***</td>
<td>-1.13 (0.17)***</td>
</tr>
<tr>
<td>featureidParent</td>
<td>-1.64 (0.13)***</td>
<td>-1.47 (0.17)***</td>
</tr>
<tr>
<td>gradebandMiddle School</td>
<td>-0.48 (0.20)*</td>
<td>-0.92 (0.26)***</td>
</tr>
<tr>
<td>gradebandHigh School</td>
<td>-1.92 (0.20)***</td>
<td>-1.94 (0.25)***</td>
</tr>
<tr>
<td>ses2Low</td>
<td>0.28 (0.11)**</td>
<td>0.08 (0.23)</td>
</tr>
<tr>
<td>(exp - 14.44903)/8.234524</td>
<td>-0.18 (0.05)***</td>
<td>-0.18 (0.05)***</td>
</tr>
<tr>
<td>featureidInteractive:gradebandMiddle School</td>
<td>-0.90 (0.22)***</td>
<td>-0.57 (0.29)***</td>
</tr>
<tr>
<td>featureid</td>
<td>gradeband</td>
<td>Model 1</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
<td>------------</td>
</tr>
<tr>
<td>Practice</td>
<td>Middle School</td>
<td>0.24 (0.26)</td>
</tr>
<tr>
<td>Adaptive</td>
<td>Middle School</td>
<td>-0.79 (0.22)</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>Middle School</td>
<td>0.48 (0.23) *</td>
</tr>
<tr>
<td>Parent</td>
<td>Middle School</td>
<td>0.86 (0.22)</td>
</tr>
<tr>
<td>Interactive</td>
<td>High School</td>
<td>0.59 (0.22) **</td>
</tr>
<tr>
<td>Practice</td>
<td>High School</td>
<td>-0.01 (0.24)</td>
</tr>
<tr>
<td>Adaptive</td>
<td>High School</td>
<td>-2.45 (0.27) ***</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>High School</td>
<td>2.09 (0.23) ***</td>
</tr>
<tr>
<td>Parent</td>
<td>High School</td>
<td>1.11 (0.22) ***</td>
</tr>
<tr>
<td>Interactive</td>
<td>ses2Low</td>
<td>0.18 (0.26)</td>
</tr>
<tr>
<td>Practice</td>
<td>ses2Low</td>
<td>-0.29 (0.26)</td>
</tr>
<tr>
<td>Adaptive</td>
<td>ses2Low</td>
<td>-0.03 (0.26)</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>ses2Low</td>
<td>-0.35 (0.26)</td>
</tr>
<tr>
<td>Middle School:ses2Low</td>
<td>1.15 (0.42) **</td>
<td>0.04 (0.43)</td>
</tr>
<tr>
<td>High School:ses2Low</td>
<td>0.30 (0.47)</td>
<td>0.11 (0.52)</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>Middle School:ses2Low</td>
<td>-0.33 (0.47)</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>High School:ses2Low</td>
<td>-0.18 (0.48)</td>
</tr>
<tr>
<td>Practice</td>
<td>High School:ses2Low</td>
<td>0.81 (0.57)</td>
</tr>
<tr>
<td>Parent</td>
<td>High School:ses2Low</td>
<td>0.30 (0.47)</td>
</tr>
<tr>
<td>AIC</td>
<td>11482.37</td>
<td>11475.27</td>
</tr>
<tr>
<td>BIC</td>
<td>11636.13</td>
<td>11753.51</td>
</tr>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>-5720.18</td>
<td>-5699.63</td>
</tr>
<tr>
<td>Num. obs.</td>
<td>11184</td>
<td>11184</td>
</tr>
<tr>
<td>Num. groups: teacherid</td>
<td>1864</td>
<td>1864</td>
</tr>
<tr>
<td>Var: teacherid (Intercept)</td>
<td>3.39</td>
<td>3.37</td>
</tr>
</tbody>
</table>
## Final Model Parameter Estimates

### Table 6

**Final Model Parameter Estimates**

```r
texreg::knitreg(list(fit_int3,  
texreghelper::extract_glmer_exp(fit_int3)),  
custom.model.names = c("b (SE)", "OR [95 CI]"),  
ci.test = 1,  
caption = "Final Model",  
single.row = TRUE)
```

<table>
<thead>
<tr>
<th></th>
<th>b (SE)</th>
<th>OR [95 CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>2.12 (0.16)</td>
<td>8.29 [6.05; 11.35] *</td>
</tr>
<tr>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>featureidInteractive</td>
<td>-1.20 (0.17)</td>
<td>0.30 [0.21; 0.42] *</td>
</tr>
<tr>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>featureidPractice</td>
<td>0.70 (0.20)</td>
<td>2.02 [1.35; 3.01] *</td>
</tr>
<tr>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>featureidAdaptive</td>
<td>-0.80 (0.18)</td>
<td>0.45 [0.32; 0.64] *</td>
</tr>
<tr>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>featureidCreate/Revise</td>
<td>-1.13 (0.17)</td>
<td>0.32 [0.23; 0.46] *</td>
</tr>
<tr>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>featureidParent</td>
<td>-1.47 (0.17)</td>
<td>0.23 [0.16; 0.32] *</td>
</tr>
<tr>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>gradebandMiddle School</td>
<td>-0.92 (0.26)</td>
<td>0.40 [0.24; 0.66] *</td>
</tr>
<tr>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>gradebandHigh School</td>
<td>-1.94 (0.25)</td>
<td>0.14 [0.09; 0.23] *</td>
</tr>
<tr>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>ses2Low</td>
<td>0.08 (0.23)</td>
<td>1.08 [0.68; 1.71]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(exp - 14.44903)/8.234524</td>
<td>-0.18 (0.05)</td>
<td>0.84 [0.76; 0.93] *</td>
</tr>
<tr>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>featureidInteractive:gradebandMiddle School</td>
<td>-0.57 (0.29) *</td>
<td>0.57 [0.32; 1.01]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>featureidPractice:gradebandMiddle School</td>
<td>0.43 (0.33)</td>
<td>1.53 [0.80; 2.94]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>featureidAdaptive:gradebandMiddle School</td>
<td>-1.11 (0.29) *</td>
<td>0.33 [0.19; 0.59] *</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandMiddle School</td>
<td>0.58 (0.29) *</td>
<td>1.78 [1.01; 3.16] *</td>
</tr>
</tbody>
</table>
```
<table>
<thead>
<tr>
<th>featureid</th>
<th>b (SE)</th>
<th>OR [95 CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>featureidParent:gradebandMiddle School</td>
<td>0.70 (0.29) *</td>
<td>2.02 [1.14; 3.56] *</td>
</tr>
<tr>
<td>featureidInteractive:gradebandHigh School</td>
<td>0.67 (0.28) *</td>
<td>1.96 [1.13; 3.39] *</td>
</tr>
<tr>
<td>featureidPractice:gradebandHigh School</td>
<td>-0.01 (0.30)</td>
<td>0.99 [0.55; 1.79]</td>
</tr>
<tr>
<td>featureidAdaptive:gradebandHigh School</td>
<td>-2.75 (0.34) **</td>
<td>0.06 [0.03; 0.13] *</td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandHigh School</td>
<td>2.05 (0.28) ***</td>
<td>7.74 [4.42; 13.56] *</td>
</tr>
<tr>
<td>featureidParent:gradebandHigh School</td>
<td>1.04 (0.28) ***</td>
<td>2.82 [1.63; 4.86] *</td>
</tr>
<tr>
<td>featureidInteractive:ses2Low</td>
<td>0.18 (0.26)</td>
<td>1.19 [0.72; 1.99]</td>
</tr>
<tr>
<td>featureidPractice:ses2Low</td>
<td>0.15 (0.30)</td>
<td>1.17 [0.64; 2.12]</td>
</tr>
<tr>
<td>featureidAdaptive:ses2Low</td>
<td>-0.29 (0.26)</td>
<td>0.75 [0.45; 1.26]</td>
</tr>
<tr>
<td>featureidCreate/Revise:ses2Low</td>
<td>-0.03 (0.26)</td>
<td>0.97 [0.58; 1.61]</td>
</tr>
<tr>
<td>featureidParent:ses2Low</td>
<td>-0.35 (0.26)</td>
<td>0.70 [0.42; 1.16]</td>
</tr>
<tr>
<td>gradebandMiddle School:ses2Low</td>
<td>1.15 (0.42) **</td>
<td>3.16 [1.37; 7.27] *</td>
</tr>
<tr>
<td>gradebandHigh School:ses2Low</td>
<td>-0.04 (0.43)</td>
<td>0.96 [0.41; 2.24]</td>
</tr>
<tr>
<td>featureidInteractive:gradebandMiddle School:ses2Low</td>
<td>-0.89 (0.47)</td>
<td>0.41 [0.16; 1.04]</td>
</tr>
<tr>
<td>featureidPractice:gradebandMiddle School:ses2Low</td>
<td>-0.49 (0.55)</td>
<td>0.61 [0.20; 1.83]</td>
</tr>
<tr>
<td>featureidAdaptive:gradebandMiddle School:ses2Low</td>
<td>0.68 (0.47)</td>
<td>1.98 [0.78; 5.02]</td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandMiddle School:ses2Low</td>
<td>-0.33 (0.47)</td>
<td>0.72 [0.28; 1.84]</td>
</tr>
<tr>
<td>featureidParent:gradebandMiddle School:ses2Low</td>
<td>0.30 (0.47)</td>
<td>1.35 [0.53; 3.45]</td>
</tr>
<tr>
<td>featureidInteractive:gradebandHigh School:ses2Low</td>
<td>-0.18 (0.48)</td>
<td>0.84 [0.32; 2.17]</td>
</tr>
<tr>
<td>Feature ID</td>
<td>b (SE)</td>
<td>OR [95 CI]</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>featureidPractice:gradebandHigh School:ses2Low</td>
<td>0.11 (0.52)</td>
<td>1.12 [0.40; 3.14]</td>
</tr>
<tr>
<td>featureidAdaptive:gradebandHigh School:ses2Low</td>
<td>0.81 (0.57)</td>
<td>2.25 [0.73; 6.89]</td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandHigh School:ses2Low</td>
<td>0.14 (0.50)</td>
<td>1.15 [0.43; 3.09]</td>
</tr>
<tr>
<td>featureidParent:gradebandHigh School:ses2Low</td>
<td>0.02 (0.48)</td>
<td>1.02 [0.40; 2.65]</td>
</tr>
</tbody>
</table>

- **AIC**: 11475.27
- **BIC**: 11753.51
- **Log Likelihood**: -5699.63
- **Num. obs.**: 11184
- **Num. groups: teacherid**: 1864
- **Var: teacherid (Intercept)**: 3.37
Experience Interpretation

```r
effects::Effect(focal.predictors = c("featureid","exp"),
    mod = fit_int3,
    confidence.level = 0.68) %>%
data.frame() %>%
ggplot(aes(x=exp,
    y=fit,
    group = featureid)) +
geom_point()+
geom_line(aes(linetype = featureid))
```

Holding feature type, grade band, ses, and all their interaction variables constant, for every year increase in teacher experience, a teacher would have 0.84 times lower odds of having access to feature.
### 3-Way Interaction Tables and Plots

**Table F-1**

Predicted Probability of Access by Feature, SES, and Grade Band effects::Effect(focal.predictors = c("featureid","gradeband","ses2"),
mod = fit_int3,
confidence.level = 0.68) %>%
data.frame() %>%
dplyr::mutate(ses2 = ses2 %>% forcats::fct_rev()) %>%
dplyr::mutate(gradeband = gradeband %>% forcats::fct_recode("High" = "High School",
"Middle" = "Middle School",
"Elementary" = "Elementary")
)
%>

dplyr::mutate_at(vars(fit, lower, upper),
MOTE::apa,
decimals = 3,
leading = FALSE) %>%
dplyr::mutate(text = glue::glue("{fit} [{lower}, {upper}]")) %>
%
dplyr::select(featureid, gradeband, ses2, text) %>%
tidyrr::pivot_wider(names_from = gradeband,
values_from = text) %>%
dplyr::arrange(featureid, ses2) %>%
pander::pander(caption = "Predicted Probability of Access by SES, Gradeband, and Feature Type")

<table>
<thead>
<tr>
<th>featureid</th>
<th>ses2</th>
<th>Elementary</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Videos</td>
<td>Low</td>
<td>.900 [.883, .914]</td>
<td>.919 [.894, .938]</td>
<td>.553 [.477, .626]</td>
</tr>
<tr>
<td>Videos</td>
<td>High</td>
<td>.892 [.876, .907]</td>
<td>.767 [.729, .801]</td>
<td>.543 [.496, .589]</td>
</tr>
<tr>
<td>Interactive</td>
<td>Low</td>
<td>.763 [.734, .789]</td>
<td>.485 [.428, .543]</td>
<td>.421 [.350, .496]</td>
</tr>
<tr>
<td>Practice</td>
<td>Low</td>
<td>.955 [.945, .963]</td>
<td>.961 [.947, .972]</td>
<td>.763 [.700, .816]</td>
</tr>
<tr>
<td>Practice</td>
<td>High</td>
<td>.944 [.933, .952]</td>
<td>.911 [.890, .928]</td>
<td>.703 [.661, .742]</td>
</tr>
<tr>
<td>Adaptive</td>
<td>Low</td>
<td>.752 [.722, .779]</td>
<td>.712 [.661, .759]</td>
<td>.057 [.040, .080]</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>Low</td>
<td>.737 [.707, .765]</td>
<td>.819 [.779, .854]</td>
<td>.776 [.715, .827]</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>High</td>
<td>.729 [.700, .755]</td>
<td>.656 [.610, .698]</td>
<td>.748 [.710, .784]</td>
</tr>
<tr>
<td>featureid</td>
<td>ses2</td>
<td>Elementary</td>
<td>Middle</td>
<td>High</td>
</tr>
<tr>
<td>-----------</td>
<td>------</td>
<td>------------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Parent</td>
<td>Low</td>
<td>.591 [.556, .625]</td>
<td>.832 [.793, .865]</td>
<td>.365 [.298, .437]</td>
</tr>
<tr>
<td>Parent</td>
<td>High</td>
<td>.655 [.624, .685]</td>
<td>.604 [.557, .649]</td>
<td>.434 [.388, .481]</td>
</tr>
</tbody>
</table>
Table F-2

Feature Comparisons of Predicted Probability of Access within SES, by Grade Band

tibble::glimpse(data_long_JH)
## Rows: 11,184
## Columns: 16
## $ weight       <dbl> 27.42666, 27.42666, 27.42666, 27.42666, 2
## $ weight_state <fct> NM, NM, NM, NM, NM, Other, Other, Other...
## $ teacherid    <fct> T000298, T000298, T000298, T000298, T0002
## $ feature      <fct> adaptive, createrevise, interactive, pare
## $ gradeband    <fct> Elementary, Elementary, Elementary, Eleme
## $ pct_frp     <fct> 50-75%, 50-75%, 50-75%, 50-75%, 5
## $ exp          <int> 17, 17, 17, 17, 17, 17, 10, 10, 10, 1
## $ some_req     <fct> Yes, Yes, Yes, No, Yes, Yes, No, No, No, ...  
## $ access       <fct> Yes, Yes, Yes, No, Yes, Yes, No, No, No, ...
## $ type_user    <fct> User of 29 Programs, User of 29 Programs,
## $ accessN      <dbl> 1, 1, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 1, ... 
## $ featureid    <fct> Adaptive, Create/Revise, Interactive, Parent...
## $ ses          <fct> Med-low, Med-low, Med-low, Med-low, Med-
## $ ses2         <fct> Low, Low, Low, Low, Low, High, High, ... 
## $ choiceN      <dbl> 0, 0, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, ...
## $ choice       <fct> No, No, No, Yes, No, No, Yes, Yes, Yes, Y

levels(data_long_JH$featureid)
## [1] "Videos"        "Interactive"   "Practice"      "Adaptive"
## [5] "Create/Revise" "Parent"

levels(data_long_JH$gradeband)
## [1] "Elementary"    "Middle School" "High School"
levels(data_long_JH$ses2)
## [1] "High" "Low"

#Reorder variables first
data_long_JH <- data_long_JH %>%
dplyr::mutate(featureid = featureid %>%
  factor(levels = c("Practice","Videos","Interactive", "Adaptive","Parent","Create/Revise"))) %>%
dplyr::mutate(gradeband = gradeband %>%
 forcats::fct_recode("High" = "High School",
  "Middle" = "Middle School",
  "Elementary" ="Elementary")
) %>%
dplyr::mutate(ses2 = ses2 %>%
  factor(levels = c("Low","High")))

#emmeans
fit_int3 %>%
  emmeans::emmeans(~ featureid | ses2*gradeband) %>%
pairs(adjust = "Tukey") %>%
data.frame() %>%
dplyr::mutate(p.value = pval_label_apa(p.value)) %>%
dplyr::select(contrast, gradeband, ses2, p.value) %>%
tidyr::pivot_wider(names_from = c(gradeband),
  #names_glue = "{gradeband}_{ses2}",
  values_from = p.value) %>%
dplyr::arrange(contrast) %>%
pander::pander(caption = "Predicted Probability of Access Comparing Feature Type within Gradeband, by SES")

<p>| Predicted Probability of Access Comparing Feature Type within Gradeband, by SES |
|--------------------------------|-----------------|----------------|----------------|--------------------|
| contrast  | ses2  | Elementary | Middle | High  |
| Practice - Videos | Low  | p &lt; .001 *** | p &lt; .001 *** | p = .136 |</p>
<table>
<thead>
<tr>
<th>contrast</th>
<th>ses2</th>
<th>Elementary</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice - Videos</td>
<td>High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p = .638</td>
</tr>
<tr>
<td>Practice - Interactive</td>
<td>Low</td>
<td>p = .007 **</td>
<td>p &lt; .001 ***</td>
<td>p = .021 *</td>
</tr>
<tr>
<td>Practice - Interactive</td>
<td>High</td>
<td>p = .002 **</td>
<td>p = .315</td>
<td>p = .087</td>
</tr>
<tr>
<td>Practice - Adaptive</td>
<td>Low</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Practice - Adaptive</td>
<td>High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Practice - Parent</td>
<td>Low</td>
<td>p &lt; .001 ***</td>
<td>p = .160</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Practice - Parent</td>
<td>High</td>
<td>p &lt; .001 ***</td>
<td>p = .056</td>
<td>p = .054</td>
</tr>
<tr>
<td>Practice - (Create/Revise)</td>
<td>Low</td>
<td>p &lt; .001 ***</td>
<td>p = .010 **</td>
<td>p = .323</td>
</tr>
<tr>
<td>Practice - (Create/Revise)</td>
<td>High</td>
<td>p &lt; .001 ***</td>
<td>p = .117</td>
<td>p = .230</td>
</tr>
<tr>
<td>Videos - Interactive</td>
<td>Low</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Videos - Interactive</td>
<td>High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Videos - Adaptive</td>
<td>Low</td>
<td>p = .127</td>
<td>p = .986</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Videos - Adaptive</td>
<td>High</td>
<td>p = .999</td>
<td>p = .005 **</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Videos - Parent</td>
<td>Low</td>
<td>p = .997</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Videos - Parent</td>
<td>High</td>
<td>p = .971</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Videos - (Create/Revise)</td>
<td>Low</td>
<td>p = .518</td>
<td>p &lt; .001 ***</td>
<td>p = .998</td>
</tr>
<tr>
<td>Videos - (Create/Revise)</td>
<td>High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p = .984</td>
</tr>
<tr>
<td>Interactive - Adaptive</td>
<td>Low</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Interactive - Adaptive</td>
<td>High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Interactive - Parent</td>
<td>Low</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p = .914</td>
</tr>
<tr>
<td>Interactive - Parent</td>
<td>High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p = 1.000</td>
</tr>
<tr>
<td>Interactive - (Create/Revise)</td>
<td>Low</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Interactive - (Create/Revise)</td>
<td>High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Adaptive - Parent</td>
<td>Low</td>
<td>p = .333</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Adaptive - Parent</td>
<td>High</td>
<td>p = .998</td>
<td>p = .277</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Adaptive - (Create/Revise)</td>
<td>Low</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Adaptive - (Create/Revise)</td>
<td>High</td>
<td>p &lt; .001 ***</td>
<td>p = .153</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Parent - (Create/Revise)</td>
<td>Low</td>
<td>p = .241</td>
<td>p = .919</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Parent - (Create/Revise)</td>
<td>High</td>
<td>p = .001 **</td>
<td>p = 1.000</td>
<td>p &lt; .001 ***</td>
</tr>
</tbody>
</table>

#put all factor levels back for code below this.
data_long_JH <- data_long_JH %>%
  dplyr::mutate(featureid = featureid %>%
                 factor(levels=c("Videos", "Interactive", 'Practice'),
                 ...)
dplyr::mutate(gradeband = gradeband %>%
 forcats::fct_recode("High School" = "High",
  "Middle School" = "Middle",
  "Elementary" = "Elementary")
)

dplyr::mutate(ses2 = ses2 %>%
  factor(levels = c("High","Low")))
Table F-3

*Grade Band Comparisons of Predicted Probability of Access within SES, by Feature*

```r
fit_int3 %>%
  emmeans::emmeans(~ gradeband | ses2*featureid) %>%
pairs(adj = "none") %>%
data.frame() %>%
dplyr::mutate(p.value = pval_label_apa(p.value)) %>%
dplyr::select(featureid, ses2, contrast, p.value) %>%
dplyr::mutate(ses2 = ses2 %>%
 forcats::fct_rev()) %>%
dplyr::mutate(contrast = contrast %>%
 forcats::fct_recode("Elementary - Middle" = "Elementary - Middle School",
  "Middle - High" = "Middle School - High School",
  "Elementary - High" = "Elementary - High School")) %>%
dplyr::mutate(contrast = contrast %>%
  factor(levels=c("Elementary - Middle",
  "Middle - High",
  "Elementary - High"))) %>%
dplyr::arrange(featureid, ses2, contrast) %>%
tidyr::pivot_wider(names_from = ses2,
  values_from = p.value) %>%
dplyr::arrange(featureid, contrast) %>%
pander::pander(caption = "Predicted Probability of Access Comparing Gradeband within SES, by Feature Type")
```

<table>
<thead>
<tr>
<th>featureid</th>
<th>contrast</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Videos</td>
<td>Elementary - Middle</td>
<td>p = .493</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Videos</td>
<td>Middle - High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Videos</td>
<td>Elementary - High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Interactive</td>
<td>Elementary - Middle</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Interactive</td>
<td>Middle - High</td>
<td>p = .499</td>
<td>p = .419</td>
</tr>
<tr>
<td>Interactive</td>
<td>Elementary - High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Practice</td>
<td>Elementary - Middle</td>
<td>p = .672</td>
<td>p = .089</td>
</tr>
<tr>
<td>Practice</td>
<td>Middle - High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>Practice</td>
<td>Elementary - High</td>
<td>p &lt; .001 ***</td>
<td>p &lt; .001 ***</td>
</tr>
<tr>
<td>featureid</td>
<td>contrast</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------</td>
<td>-----------</td>
<td>------------</td>
</tr>
<tr>
<td>Adaptive</td>
<td>Elementary - Middle</td>
<td>$p = .482$</td>
<td>$p &lt; .001$ ***</td>
</tr>
<tr>
<td>Adaptive</td>
<td>Middle - High</td>
<td>$p &lt; .001$ ***</td>
<td>$p &lt; .001$ ***</td>
</tr>
<tr>
<td>Adaptive</td>
<td>Elementary - High</td>
<td>$p &lt; .001$ ***</td>
<td>$p &lt; .001$ ***</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>Elementary - Middle</td>
<td>$p = .103$</td>
<td>$p = .153$</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>Middle - High</td>
<td>$p = .507$</td>
<td>$p = .107$</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>Elementary - High</td>
<td>$p = .560$</td>
<td>$p = .669$</td>
</tr>
<tr>
<td>Parent</td>
<td>Elementary - Middle</td>
<td>$p &lt; .001$ ***</td>
<td>$p = .353$</td>
</tr>
<tr>
<td>Parent</td>
<td>Middle - High</td>
<td>$p &lt; .001$ ***</td>
<td>$p = .011$ *</td>
</tr>
<tr>
<td>Parent</td>
<td>Elementary - High</td>
<td>$p = .006$ **</td>
<td>$p &lt; .001$ ***</td>
</tr>
</tbody>
</table>
Table F-4

**SES Comparisons of Predicted Probability of Access within Grade Band, by Feature**

```r
fit_int3 %>%
  emmeans::emmeans(~ ses2 | gradeband*featureid) %>%
pairs(adjust = "none") %>%
data.frame() %>%
dplyr::mutate(contrast = contrast %>%
  forcats::fct_rev()) %>%
dplyr::mutate(gradeband = gradeband %>%
  forcats::fct_recode("High" = "High School",
                     "Middle" = "Middle School",
                     "Elementary" = "Elementary")
)
%>%
dplyr::arrange(contrast) %>%
dplyr::mutate(p.value = pval_label_apa(p.value)) %>%
dplyr::select(contrast, featureid, gradeband, p.value) %>%
tidyr::pivot_wider(names_from = gradeband,
                   values_from = p.value) %>%
pander::pander(caption = "Predicted Probability of Access Comparing SES within Gradeband, by Feature Type")
```

<table>
<thead>
<tr>
<th>contrast</th>
<th>featureid</th>
<th>Elementary</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>High - Low</td>
<td>Videos</td>
<td>p = .734</td>
<td>p &lt; .001 ***</td>
<td>p = .910</td>
</tr>
<tr>
<td>High - Low</td>
<td>Interactive</td>
<td>p = .215</td>
<td>p = .088</td>
<td>p = .912</td>
</tr>
<tr>
<td>High - Low</td>
<td>Practice</td>
<td>p = .382</td>
<td>p = .028 *</td>
<td>p = .414</td>
</tr>
<tr>
<td>High - Low</td>
<td>Adaptive</td>
<td>p = .320</td>
<td>p &lt; .001 ***</td>
<td>p = .214</td>
</tr>
<tr>
<td>High - Low</td>
<td>Create/Revise</td>
<td>p = .827</td>
<td>p = .007 **</td>
<td>p = .694</td>
</tr>
<tr>
<td>High - Low</td>
<td>Parent</td>
<td>p = .171</td>
<td>p &lt; .001 ***</td>
<td>p = .421</td>
</tr>
</tbody>
</table>
effects::Effect(focal.predictors = c("featureid", "gradeband", "ses 2"),
    mod = fit_int3) %>%
data.frame %>%
ggplot(aes(x=featureid,
    y=fit,
    group = gradeband)) +
geom_point(aes(shape=gradeband,
    color=gradeband),
    position = position_dodge(.20)) +
facet_grid(rows = vars(ses2)) +
geom_line(aes(linetype = gradeband,
    color = gradeband)) +
theme_bw() +
labs(y = "Predicted Probability")
effects::Effect(focal.predictors = c("featureid","gradeband","ses 2"),
    mod = fit_int3) %>%
data.frame() %>%
dplyr::mutate(ses2 = ses2 %>%
   forcats::fct_recode("Low SES Schools: > 50% FRP L" = "Low",
                       "High SES Schools: < 50% FR PL" = "High")
) %>%
ggplot(aes(x=featureid,
    y=fit,
    group = gradeband)) +
geom_point(aes(shape=gradeband),
    size = 1.5,
    position = position_dodge(.20)) +
facet_wrap(~ ses2, ncol = 1) +
geom_line(aes(linetype = gradeband),
    position = position_dodge(.20)) +
theme_bw() +
labs(x = "Feature Type",
    y = "Predicted Probability for Access",
    shape = "Gradeband: ",
    linetype = "Gradeband: ") +
theme(legend.position = "bottom") +
theme(legend.key.width = unit(1.5, "cm"))
effects::Effect(focal.predictors = c("featureid", "gradeband", "ses 2"),
    mod = fit_int3) %>%
data.frame() %>%
dplyr::mutate(ses2 = ses2 %>%
    forcats::fct_recode("Low SES Schools: > 50% FRP L" = "Low",
                        "High SES Schools: < 50% FR PL" = "High") %>%
ggplot(aes(x = featureid,
            y = fit,
            group = ses2)) +
geom_point(aes(shape = ses2),
            size = 1.5,
            position = position_dodge(.20)) +
facet_wrap(~ gradeband, ncol = 1) +
geom_line(aes(linetype = ses2),
            position = position_dodge(.20)) +
theme_bw() +
labs(x = "Feature Type",
            y = "Predicted Probability for Access",
            shape = NULL,
            linetype = NULL) +
theme(legend.position = "bottom") +
theme(legend.key.width = unit(1.5, "cm"))
Figure 10

*Predicted Probability for Access to Feature: Interaction Effects*

```r
effects::Effect(focal.predictors = c("featureid", "gradeband", "ses 2"),
               mod = fit_int3,
               confidence.level = 0.68) %>%
data.frame() %>%
dplyr::mutate(ses2 = ses2 %>%
               forcats::fct_recode("Low (> 50%)" = "Low",
                                  "High (< 50%)" = "High") %>
               forcats::fct_rev()) %>%
dplyr::mutate(gradeband = gradeband %>%
               forcats::fct_recode("High\nSchool" = "High School",
                                   "Middle\nSchool" = "Middle School",
                                   "Elementary\nSchool" = "Elementary") %>
ggplot(aes(x=gradeband,
           y=fit,
           group = ses2)) +
geom_point(aes(shape=ses2),
           size = 2,
           position = position_dodge(.30)) +
facet_wrap(~ featureid) +
geom_line(aes(linetype = ses2),
           position = position_dodge(.30)) +
#geom_label("*") +
theme_bw() +
labs(x = NULL,
     y = "Predicted Probability for Access",
     shape = "School SES (FRPL): ",
     linetype = "School SES (FRPL): ") +
theme(legend.position = c(1, .55),
      legend.justification = c(1.1, -0.1),
      legend.background = element_rect(color = "black"),
      legend.key.width = unit(2, "cm")) +
scale_linetype_manual(values = c("longdash", "solid")) +
geom_errorbar(aes(ymin = lower,
                   ymax = upper),
             linetype = "solid",
             width = .5,
             position = position_dodge(.30))
```
ggsave(filename = "GLMM_predictions_3way_byFeature_10-15-22.png",
        width = 7,
        height = 6,
        units = "in")
Fit Int4

Tested a 3-way interaction between feature, grade band, and experience. Not significant.

```r
fit_int4 <- lme4::glmer(access ~ featureid*gradeband*I((exp - 14.44903)/8.234524) +
  ses2 +
  #choice +
  (1|teacherid),
  data = data_long_JH,
  control = glmerControl(optimizer = "bobyqa")
 ,
  family = binomial(link = "logit"))

summary(fit_int4)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
##  Formula: access ~ featureid * gradeband * I((exp - 14.44903)/8
##   .234524) +
##     ses2 + (1 | teacherid)
##  Data: data_long_JH
##  Control: glmerControl(optimizer = "bobyqa")
##
##      AIC      BIC   logLik deviance df.resid
##  11504.1  11782.3 -5714.0  11428.1    11146
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.2658 -0.4225  0.2664  0.4832  6.3073
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  teacherid (Intercept) 3.395   1.843
##  teacherid Number of obs: 11184, groups:  teacherid, 1864

## Fixed effects:
##
##    Estimate
##  (Intercept)       2.036996
## featureidInteractive
```
-1.139425
## featureidPractice
  0.756981
## featureidAdaptive
  -0.953246
## featureidCreate/Revise
  -1.157083
## featureidParent
  -1.651692
## gradebandMiddle School
  -0.499793
## gradebandHigh School
  -1.936958
## I((exp - 14.44903)/8.234524)
  -0.305587
## ses2Low
  0.278030
## featureidInteractive:gradebandMiddle School
  -0.886672
## featureidPractice:gradebandMiddle School
  0.255810
## featureidAdaptive:gradebandMiddle School
  -0.781876
## featureidCreate/Revise:gradebandMiddle School
  0.491368
## featureidParent:gradebandMiddle School
  0.874711
## featureidInteractive:gradebandHigh School
  0.612325
## featureidPractice:gradebandHigh School
  0.003853
## featureidAdaptive:gradebandHigh School
  -2.489824
## featureidCreate/Revise:gradebandHigh School
  2.110035
## featureidParent:gradebandHigh School
  1.122902
## featureidInteractive:I((exp - 14.44903)/8.234524)
  0.193656
## featureidPractice:I((exp - 14.44903)/8.234524)
  0.134290
## featureidAdaptive:I((exp - 14.44903)/8.234524)
  0.288587
## featureidCreate/Revise:I((exp - 14.44903)/8.234524)
  0.113480
## featureidParent:I((exp - 14.44903)/8.234524)
0.127257
## gradebandMiddle School:I((exp - 14.44903)/8.234524)
 0.098924
## gradebandHigh School:I((exp - 14.44903)/8.234524)
 0.233586
## featureidInteractive:gradebandMiddle School:I((exp - 14.44903)/8.234524) -0.216981
## featureidPractice:gradebandMiddle School:I((exp - 14.44903)/8.234524) -0.039584
## featureidAdaptive:gradebandMiddle School:I((exp - 14.44903)/8.234524) -0.416575
## featureidCreate/Revise:gradebandMiddle School:I((exp - 14.44903)/8.234524) -0.122158
## featureidParent:gradebandMiddle School:I((exp - 14.44903)/8.234524) -0.180155
## featureidInteractive:gradebandHigh School:I((exp - 14.44903)/8.234524) -0.311105
## featureidPractice:gradebandHigh School:I((exp - 14.44903)/8.234524) -0.100430
## featureidAdaptive:gradebandHigh School:I((exp - 14.44903)/8.234524) -0.785249
## featureidCreate/Revise:gradebandHigh School:I((exp - 14.44903)/8.234524) -0.190187
## featureidParent:gradebandHigh School:I((exp - 14.44903)/8.234524) -0.182684

## Std. Error
## (Intercept)
 0.128583
## featureidInteractive
 0.129647
## featureidPractice
 0.151968
## featureidAdaptive
 0.130270
## featureidCreate/Revise
 0.129653
## featureidParent
 0.129144
## gradebandMiddle School
 0.201665
## gradebandHigh School
 0.201350
## I((exp - 14.44903)/8.234524)
 0.115105
## ses2Low
## featureidInteractive:gradebandMiddle School 0.225615
## featureidPractice:gradebandMiddle School 0.262512
## featureidAdaptive:gradebandMiddle School 0.225439
## featureidCreate/Revise:gradebandMiddle School 0.226549
## featureidParent:gradebandMiddle School 0.225479
## featureidInteractive:gradebandHigh School 0.223932
## featureidPractice:gradebandHigh School 0.241329
## featureidAdaptive:gradebandHigh School 0.277390
## featureidCreate/Revise:gradebandHigh School 0.231046
## featureidParent:gradebandHigh School 0.223417
## featureidInteractive:I((exp - 14.44903)/8.234524) 0.128095
## featureidPractice:I((exp - 14.44903)/8.234524) 0.150451
## featureidAdaptive:I((exp - 14.44903)/8.234524) 0.129348
## featureidCreate/Revise:I((exp - 14.44903)/8.234524) 0.127908
## featureidParent:I((exp - 14.44903)/8.234524) 0.126820
## gradebandMiddle School:I((exp - 14.44903)/8.234524) 0.200754
## gradebandHigh School:I((exp - 14.44903)/8.234524) 0.195603
## featureidInteractive:gradebandMiddle School:I((exp - 14.44903)/8.234524) 0.226246
## featureidPractice:gradebandMiddle School:I((exp - 14.44903)/8.234524) 0.261175
## featureidAdaptive:gradebandMiddle School:I((exp - 14.44903)/8.234524) 0.226660
## featureidCreate/Revise:gradebandMiddle School:I((exp - 14.44903)/8.234524) 0.226593
## featureidParent:gradebandMiddle School:I((exp - 14.44903)/8.234524) 0.225578
## featureidInteractive:gradebandHigh School:I((exp - 14.44903)/8
.234524) 0.220341
## featureidPractice:gradebandHigh School: I((exp - 14.44903)/8.234524) 0.237752
## featureidAdaptive:gradebandHigh School: I((exp - 14.44903)/8.234524) 0.287837
## featureidCreate/Revise:gradebandHigh School: I((exp - 14.44903)/8.234524) 0.225326
## featureidParent:gradebandHigh School: I((exp - 14.44903)/8.234524) 0.219373
## z value
## (Intercept) 15.842
## featureidInteractive -8.789
## featureidPractice 4.981
## featureidAdaptive -7.317
## featureidCreate/Revise -8.924
## featureidParent -12.790
## gradebandMiddle School -2.478
## gradebandHigh School -9.620
## I((exp - 14.44903)/8.234524) -2.655
## ses2Low 2.616
## featureidInteractive:gradebandMiddle School -3.930
## featureidPractice:gradebandMiddle School 0.974
## featureidAdaptive:gradebandMiddle School -3.468
## featureidCreate/Revise:gradebandMiddle School 2.169
## featureidParent:gradebandMiddle School 3.879
## featureidInteractive:gradebandHigh School 2.734
## featureidPractice:gradebandHigh School 0.016
## featureidAdaptive:gradebandHigh School
<table>
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<tr>
<th>Feature ID</th>
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<th>Coefficient</th>
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<tbody>
<tr>
<td>featureidCreate/Revise:gradebandHigh School</td>
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</table>

Pr(>|z|)

(Intercept) < 2e-16
featureidInteractive < 2e-16
featureidPractice
6.32e-07
## featureAdaptive
2.53e-13
## featureCreate/Revise
< 2e-16
## featureParent
< 2e-16
## gradeM.School
0.013200
## gradeH.School
< 2e-16
## I((exp - 14.44903)/8.234524)
0.007934
## sesLow
0.008887
## featureInteractive:M.School
8.49e-05
## featurePractice:M.School
0.329823
## featureAdaptive:M.School
0.000524
## featureCreate/Revise:M.School
0.030089
## featureParent:M.School
0.000105
## featureInteractive:H.School
0.006249
## featurePractice:H.School
0.987261
## featureAdaptive:H.School
< 2e-16
## featureCreate/Revise:H.School
< 2e-16
## featureParent:H.School
5.01e-07
## featureInteractive:I((exp - 14.44903)/8.234524)
0.130579
## featurePractice:I((exp - 14.44903)/8.234524)
0.372081
## featureAdaptive:I((exp - 14.44903)/8.234524)
0.025676
## featureCreate/Revise:I((exp - 14.44903)/8.234524)
0.374970
## featureParent:I((exp - 14.44903)/8.234524)
0.315646
## gradeM.School:I((exp - 14.44903)/8.234524)
0.622180
## gradebandHigh School: I((exp - 14.44903)/8.234524) 
  0.232406
## featureidInteractive: gradebandMiddle School: I((exp - 14.44903)/8.234524) 0.337533
## featureidPractice: gradebandMiddle School: I((exp - 14.44903)/8.234524) 0.879532
## featureidAdaptive: gradebandMiddle School: I((exp - 14.44903)/8.234524) 0.066079
## featureidCreate/Revise: gradebandMiddle School: I((exp - 14.44903)/8.234524) 0.589812
## featureidParent: gradebandMiddle School: I((exp - 14.44903)/8.234524) 0.424502
## featureidInteractive: gradebandHigh School: I((exp - 14.44903)/8.234524) 0.157972
## featureidPractice: gradebandHigh School: I((exp - 14.44903)/8.234524) 0.672722
## featureidAdaptive: gradebandHigh School: I((exp - 14.44903)/8.234524) 0.006370
## featureidCreate/Revise: gradebandHigh School: I((exp - 14.44903)/8.234524) 0.398641
## featureidParent: gradebandHigh School: I((exp - 14.44903)/8.234524) 0.404983
##
## (Intercept) ***
## featureidInteractive ***
## featureidPractice ***
## featureidAdaptive ***
## featureidCreate/Revise ***
## featureidParent ***
## gradebandMiddle School *
## gradebandHigh School ***
## I((exp - 14.44903)/8.234524) **
## ses2Low **
## featureidInteractive: gradebandMiddle School
### featureidPractice:gradebandMiddle School
### featureidAdaptive:gradebandMiddle School
### featureidCreate/Revise:gradebandMiddle School
### featureidParent:gradebandMiddle School
### featureidInteractive:gradebandHigh School
### featureidPractice:gradebandHigh School
### featureidAdaptive:gradebandHigh School
### featureidCreate/Revise:gradebandHigh School
### featureidParent:gradebandHigh School
### featureidInteractive:I((exp - 14.44903)/8.234524)
### featureidPractice:I((exp - 14.44903)/8.234524)
### featureidAdaptive:I((exp - 14.44903)/8.234524)
### featureidCreate/Revise:I((exp - 14.44903)/8.234524)
### featureidParent:I((exp - 14.44903)/8.234524)
### gradebandMiddle School:I((exp - 14.44903)/8.234524)
### gradebandHigh School:I((exp - 14.44903)/8.234524)
### featureidInteractive:gradebandMiddle School:I((exp - 14.44903)/8.234524)
### featureidPractice:gradebandMiddle School:I((exp - 14.44903)/8.234524)
### featureidAdaptive:gradebandMiddle School:I((exp - 14.44903)/8.234524)
### featureidCreate/Revise:gradebandMiddle School:I((exp - 14.44903)/8.234524)
### featureidParent:gradebandMiddle School:I((exp - 14.44903)/8.234524)
### featureidInteractive:gradebandHigh School:I((exp - 14.44903)/8.234524)
### featureidPractice:gradebandHigh School:I((exp - 14.44903)/8.234524)
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation matrix not shown by default, as p = 37 > 12.  
## Use print(x, correlation=TRUE) or  
##     vcov(x) if you need it  
## optimizer (bobyqa) convergence code: 0 (OK)  
## maxfun < 10 * length(par)^2 is not recommended.

texreg::knitreg(fit_int4,  
    single.row = TRUE)

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
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</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>2.04 (0.13)</td>
</tr>
<tr>
<td></td>
<td>***</td>
</tr>
<tr>
<td>featureidInteractive</td>
<td>-1.14 (0.13)</td>
</tr>
<tr>
<td></td>
<td>***</td>
</tr>
<tr>
<td>featureidPractice</td>
<td>0.76 (0.15)</td>
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<td>featureidAdaptive</td>
<td>-0.95 (0.13)</td>
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<tr>
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<td>***</td>
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<tr>
<td>featureidCreate/Revise</td>
<td>-1.16 (0.13)</td>
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<tr>
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<td>featureidParent</td>
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<tr>
<td>gradebandMiddle School</td>
<td>-0.50 (0.20)</td>
</tr>
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<td>*</td>
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<tr>
<td>gradebandHigh School</td>
<td>-1.94 (0.20)</td>
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<td>***</td>
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<tr>
<td>(exp - 14.44903)/8.234524</td>
<td>-0.31 (0.12)</td>
</tr>
<tr>
<td></td>
<td>**</td>
</tr>
<tr>
<td>ses2Low</td>
<td>0.28 (0.11)</td>
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<td>**</td>
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<td>featureidInteractive:gradebandMiddle School</td>
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<td>***</td>
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<table>
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<td>featureidAdaptive:gradebandMiddle School</td>
<td>0.78 (0.23)</td>
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<tr>
<td>featureidCreate/Revise:gradebandMiddle School</td>
<td>0.49 (0.23)</td>
<td>*</td>
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<tr>
<td>featureidParent:gradebandMiddle School</td>
<td>0.87 (0.23)</td>
<td>** ***</td>
</tr>
<tr>
<td>featureidInteractive:gradebandHigh School</td>
<td>0.61 (0.22)</td>
<td>**</td>
</tr>
<tr>
<td>featureidPractice:gradebandHigh School</td>
<td>0.00 (0.24)</td>
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</tr>
<tr>
<td>featureidAdaptive:gradebandHigh School</td>
<td>-2.49 (0.28)</td>
<td>** ***</td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandHigh School</td>
<td>2.11 (0.23)</td>
<td>** ***</td>
</tr>
<tr>
<td>featureidParent:gradebandHigh School</td>
<td>1.12 (0.22)</td>
<td>** ***</td>
</tr>
<tr>
<td>featureidInteractive:(exp - 14.44903)/8.234524</td>
<td>0.19 (0.13)</td>
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</tr>
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<td>featureidPractice:(exp - 14.44903)/8.234524</td>
<td>0.13 (0.15)</td>
<td></td>
</tr>
<tr>
<td>featureidAdaptive:(exp - 14.44903)/8.234524</td>
<td>0.29 (0.13)</td>
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<td>0.11 (0.13)</td>
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<tr>
<td>featureidParent:(exp - 14.44903)/8.234524</td>
<td>0.13 (0.13)</td>
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<tr>
<td>gradebandMiddle School:(exp - 14.44903)/8.234524</td>
<td>0.10 (0.20)</td>
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<tr>
<td>gradebandHigh School:(exp - 14.44903)/8.234524</td>
<td>0.23 (0.20)</td>
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</tr>
<tr>
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<td>-0.22 (0.23)</td>
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<td>-0.04 (0.26)</td>
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<tr>
<td>featureidAdaptive:gradebandMiddle School:(exp - 14.44903)/8.234524</td>
<td>-0.42 (0.23)</td>
<td></td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandMiddle School:(exp - 14.44903)/8.234524</td>
<td>-0.12 (0.23)</td>
<td></td>
</tr>
<tr>
<td>featureidParent:gradebandMiddle School:(exp - 14.44903)/8.234524</td>
<td>-0.18 (0.23)</td>
<td></td>
</tr>
<tr>
<td>featureidInteractive:gradebandHigh School:(exp - 14.44903)/8.234524</td>
<td>-0.31 (0.22)</td>
<td></td>
</tr>
<tr>
<td>featureidPractice:gradebandHigh School:(exp - 14.44903)/8.234524</td>
<td>-0.10 (0.24)</td>
<td></td>
</tr>
<tr>
<td>featureidAdaptive:gradebandHigh School:(exp - 14.44903)/8.234524</td>
<td>-0.79 (0.29)</td>
<td>**</td>
</tr>
<tr>
<td>featureidCreate/Revise:gradebandHigh School:(exp - 14.44903)/8.234524</td>
<td>-0.19 (0.23)</td>
<td></td>
</tr>
<tr>
<td>featureidParent:gradebandHigh School:(exp - 14.44903)/8.234524</td>
<td>-0.18 (0.22)</td>
<td></td>
</tr>
</tbody>
</table>
Model 1

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIC</td>
<td>11504.06</td>
</tr>
<tr>
<td>BIC</td>
<td>11782.31</td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>-5714.03</td>
</tr>
<tr>
<td>Num. obs.</td>
<td>11184</td>
</tr>
<tr>
<td>Num. groups: teacherid</td>
<td>1864</td>
</tr>
<tr>
<td>Var: teacherid (Intercept)</td>
<td>3.40</td>
</tr>
</tbody>
</table>

```r
anova(fit_int3, fit_int4)
```

```
## Data: data_long_JH
## Models:
## fit_int3: accessN ~ featureid * gradeband * ses2 + I((exp - 14.44903)/8.234524) + (1 | teacherid)
## fit_int4: access ~ featureid * gradeband * I((exp - 14.44903)/8.234524) + ses2 + (1 | teacherid)
## npar  AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## fit_int3   38 11475 11754 -5699.6   11399
## fit_int4   38 11504 11782 -5714.0   11428   0    0
```
## Table F-1

*Predicted Probability of Access by Feature, SES, and Grade Band*

<table>
<thead>
<tr>
<th>Feature</th>
<th>SES</th>
<th>Elementary 95% CI</th>
<th>Middle 95% CI</th>
<th>High 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Videos</td>
<td>Low</td>
<td>.900 [.883, .914]</td>
<td>.919 [.894, .938]</td>
<td>.553 [.477, .626]</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>.892 [.876, .907]</td>
<td>.767 [.729, .801]</td>
<td>.543 [.496, .589]</td>
</tr>
<tr>
<td>Interactive</td>
<td>Low</td>
<td>.763 [.734, .789]</td>
<td>.485 [.428, .543]</td>
<td>.421 [.350, .496]</td>
</tr>
<tr>
<td>Practice</td>
<td>Low</td>
<td>.955 [.945, .963]</td>
<td>.961 [.947, .972]</td>
<td>.763 [.700, .816]</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>.944 [.933, .952]</td>
<td>.911 [.890, .928]</td>
<td>.703 [.661, .742]</td>
</tr>
<tr>
<td>Adaptive</td>
<td>Low</td>
<td>.752 [.722, .779]</td>
<td>.712 [.661, .759]</td>
<td>.057 [.040, .080]</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>.788 [.763, .811]</td>
<td>.327 [.286, .371]</td>
<td>.033 [.026, .043]</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>Low</td>
<td>.737 [.707, .765]</td>
<td>.819 [.779, .854]</td>
<td>.776 [.715, .827]</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>.729 [.700, .755]</td>
<td>.656 [.610, .698]</td>
<td>.748 [.710, .784]</td>
</tr>
<tr>
<td>Parent</td>
<td>Low</td>
<td>.591 [.556, .625]</td>
<td>.832 [.793, .865]</td>
<td>.365 [.298, .437]</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>.655 [.624, .685]</td>
<td>.604 [.557, .649]</td>
<td>.434 [.388, .481]</td>
</tr>
</tbody>
</table>

*Note.* Socioeconomic Status (SES) captures the percent of free or reduced-price lunch (FRPL) at the teacher’s school: High SES = FRPL < 50%, Low SES = FRPL > 50%
Table F-2

*Feature Comparisons of Predicted Probability of Access within SES, by Grade Band*

<table>
<thead>
<tr>
<th>Feature Contrast</th>
<th>SES</th>
<th>Elementary</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice - Videos</td>
<td>Low</td>
<td>(p = .002) **</td>
<td>(p = .315)</td>
<td>(p = .087)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p = .007) **</td>
<td>(p &lt; .001) ***</td>
<td>(p = .021) *</td>
</tr>
<tr>
<td>Practice - Interactive</td>
<td>Low</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td>Practice - Adaptive</td>
<td>Low</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td>Practice - Parent</td>
<td>Low</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td>Practice - Create/Revise</td>
<td>Low</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p = 1.000)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p = .914)</td>
</tr>
<tr>
<td>Videos - Interactive</td>
<td>Low</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p = .638)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p = .136)</td>
</tr>
<tr>
<td>Videos - Adaptive</td>
<td>Low</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td>Videos - Parent</td>
<td>Low</td>
<td>(p &lt; .001) ***</td>
<td>(p = .117)</td>
<td>(p = .230)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p &lt; .001) ***</td>
<td>(p = .010) **</td>
<td>(p = .323)</td>
</tr>
<tr>
<td>Videos - Create/Revise</td>
<td>Low</td>
<td>(p &lt; .001) ***</td>
<td>(p = .056)</td>
<td>(p = .054)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p &lt; .001) ***</td>
<td>(p = .160)</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td>Interactive - Adaptive</td>
<td>Low</td>
<td>(p = .999)</td>
<td>(p = .005) **</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p = .127)</td>
<td>(p = .986)</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td>Interactive - Parent</td>
<td>Low</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p = .984)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p = .518)</td>
<td>(p &lt; .001) ***</td>
<td>(p = .998)</td>
</tr>
<tr>
<td>Interactive - Create/Revise</td>
<td>Low</td>
<td>(p = .971)</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p = .997)</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td>Adaptive - Parent</td>
<td>Low</td>
<td>(p &lt; .001) ***</td>
<td>(p = .153)</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td>Adaptive - Create/Revise</td>
<td>Low</td>
<td>(p = .998)</td>
<td>(p = .277)</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p = .333)</td>
<td>(p &lt; .001) ***</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td>Parent - Create/Revise</td>
<td>Low</td>
<td>(p = .001) **</td>
<td>(p = 1.000)</td>
<td>(p &lt; .001) ***</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(p = .241)</td>
<td>(p = .919)</td>
<td>(p &lt; .001) ***</td>
</tr>
</tbody>
</table>

*Note.* Socioeconomic Status (SES) captures the percent of free or reduced-price lunch (FRPL) at the teacher’s school: High SES = FRPL < 50%, Low SES = FRPL > 50%.
Table F-3

Grade Band Comparisons of Predicted Probability of Access within SES, by Feature

<table>
<thead>
<tr>
<th>Feature</th>
<th>Grade Band Contrast</th>
<th>SES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Videos</td>
<td>Elementary - Middle</td>
<td>$p &lt; .001^{***}$</td>
</tr>
<tr>
<td></td>
<td>Middle - High</td>
<td>$p &lt; .001^{***}$</td>
</tr>
<tr>
<td></td>
<td>Elementary - High</td>
<td>$p &lt; .001^{***}$</td>
</tr>
<tr>
<td></td>
<td>Elementary - Middle</td>
<td>$p &lt; .001^{***}$</td>
</tr>
<tr>
<td>Interactive</td>
<td>Middle - High</td>
<td>$p = .419$</td>
</tr>
<tr>
<td></td>
<td>Elementary - High</td>
<td>$p &lt; .001^{***}$</td>
</tr>
<tr>
<td></td>
<td>Elementary - Middle</td>
<td>$p = .089$</td>
</tr>
<tr>
<td>Practice</td>
<td>Middle - High</td>
<td>$p &lt; .001^{***}$</td>
</tr>
<tr>
<td></td>
<td>Elementary - High</td>
<td>$p &lt; .001^{***}$</td>
</tr>
<tr>
<td></td>
<td>Elementary - Middle</td>
<td>$p &lt; .001^{***}$</td>
</tr>
<tr>
<td>Adaptive</td>
<td>Middle - High</td>
<td>$p &lt; .001^{***}$</td>
</tr>
<tr>
<td></td>
<td>Elementary - High</td>
<td>$p &lt; .001^{***}$</td>
</tr>
<tr>
<td></td>
<td>Elementary - Middle</td>
<td>$p = .153$</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>Middle - High</td>
<td>$p = .107$</td>
</tr>
<tr>
<td></td>
<td>Elementary - High</td>
<td>$p = .669$</td>
</tr>
<tr>
<td></td>
<td>Elementary - Middle</td>
<td>$p = .353$</td>
</tr>
<tr>
<td>Parent</td>
<td>Middle - High</td>
<td>$p = .011^{*}$</td>
</tr>
<tr>
<td></td>
<td>Elementary - High</td>
<td>$p &lt; .001^{***}$</td>
</tr>
</tbody>
</table>

Note. Socioeconomic Status (SES) captures the percent of free or reduced-price lunch (FRPL) at the teacher’s school: High SES = FRPL < 50%, Low SES = FRPL > 50%
Table F-4

*SES Comparisons of Predicted Probability of Access within Grade Band, by Feature*

<table>
<thead>
<tr>
<th>Feature</th>
<th>Elementary</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Videos</td>
<td>$p = .734$</td>
<td>$p &lt; .001$ ***</td>
<td>$p = .910$</td>
</tr>
<tr>
<td>Interactive</td>
<td>$p = .215$</td>
<td>$p = .088$</td>
<td>$p = .912$</td>
</tr>
<tr>
<td>Practice</td>
<td>$p = .382$</td>
<td>$p = .028$ *</td>
<td>$p = .414$</td>
</tr>
<tr>
<td>Adaptive</td>
<td>$p = .320$</td>
<td>$p &lt; .001$ ***</td>
<td>$p = .214$</td>
</tr>
<tr>
<td>Create/Revise</td>
<td>$p = .827$</td>
<td>$p = .007$ **</td>
<td>$p = .694$</td>
</tr>
<tr>
<td>Parent</td>
<td>$p = .171$</td>
<td>$p &lt; .001$ ***</td>
<td>$p = .421$</td>
</tr>
</tbody>
</table>

*Note. Socioeconomic Status (SES) captures the percent of free or reduced-price lunch (FRPL) at the teacher’s school: High SES = FRPL < 50%, Low SES = FRPL > 50%*
CURRICULUM VITAE

M. JILL HARMON

EDUCATION

Ph.D. in Education, Utah State University - Expected 2023
  Specialization: Curriculum and Instruction
  Concentration: Mathematics Education and Leadership

M.M. Mathematics, Utah State University - August 2016

B.S. Mathematics Education, Brigham Young University – April 2011
  Student Teaching at Mountain View High School – January - April 2011
  Brigham Young Scholarship, Brigham Young University – August 2010

Teaching Certificates:
  Utah Professional Teaching Level I License, 6-12, Math Level IV endorsement (2011)
  Utah Professional Teaching Level II License, 6-12, Math Level IV endorsement (2014)

A.S. University Studies, Utah Valley University – April 2009

EMPLOYMENT HISTORY

Graduate Research and Teaching Assistant 2016-2018
Utah State University, School of Teacher Education and Leadership, Logan, UT
  • Research conducted on Digital Math Apps has yielded 1 award, 3 journal articles, 1 book chapter, 4 conference proceedings, and 7 national presentations
  • Taught ELED 4061 and ELED 4062: math methods for preservice elementary educators
  • Contributed to the content of ELED 4061 (online) and was the initial instructor (including basic html for improved video player embedding in Canvas)

Graduate Research Assistant 2015-2016
Utah State University, School of Teacher Education and Leadership, Logan, UT
  • Research conducted on tasks to promote reversibility yielded 1 conference proceeding and 4 presentations
  • Conducted pre, mid, post assessments using TEMA
  • Qualitative coding analysis using pivot tables in Excel
Mathematics Teacher  
Mountainville Academy, Alpine, UT  
- Taught Secondary Math II, Secondary Math I, 8th grade math, 7th grade math, 6th grade math, including various Honors and Remedial courses, and Financial Literacy  
- Developed weekly google sheets budgeting activity based on the Game of Life game  
- Conducted a Google Sites training for fellow middle school teachers

Mathematics Teacher  
Joel P Jensen Middle School, West Jordan, UT  
- 7th grade Math, 8th grade Math, and 8th grade Math Honors  
- Taught lessons in the new Utah Core Standards based on CCSSM  
- Assisted in writing and creating district-wide access to lessons and assessments

AWARDS


RESEARCH PROJECTS

Affordances of Virtual Manipulatives (2016 - Present). Develop iPad-based interview protocols, conduct iPad-based interviews with participants, collect and code data, and analyze data. Utah State University (with PI Dr. Patricia Moyer-Packenham and the Virtual Manipulatives Research Group). My roll: conduct and analyze interviews for 2nd and 3rd grade students.

PUBLICATIONS

Journal Articles (Refereed)


Book Chapters (Refereed)


Conference Proceedings


PRESENTATIONS

National Presentations


State & Regional Presentations


UNIVERSITY TEACHING

Utah State University, Logan, Utah (2016-2018)

College of Education and Human Services

- **ELED 4061 (Online Format)** —Teaching Mathematics and Practicum Level III – Part I
  Undergraduate Course. Relevant mathematics instruction in the elementary and middle-level curriculum; methods of instruction, evaluation, remediation, and enrichment. Included the six-week supervision of Level III practicum students in participating public school settings.

- **ELED 4062 (Traditional Format)** —Teaching Mathematics and Practicum Level III – Part II
  Undergraduate Course. Relevant mathematics instruction in the elementary and middle-level curriculum; methods of instruction, evaluation, remediation, and enrichment. Included the six-week supervision of Level III practicum students in participating public school settings.

OUTREACH

Math Curriculum Specialist – Mbale, Uganda

Sustainable Education, Economics, and Engineering (SEEEME)

- Professional development training on abacus which groups in 5’s to expand number sense
- Math & Music lesson to demonstrate using new supplied abacuses
- Street Math vs School Math professional development training
- Math Fact Game lesson to demonstrate benefits of games to promote math fact fluency

July 2018
MEMBERSHIPS

<table>
<thead>
<tr>
<th>Organization</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Society for Information Technology &amp; Teacher Education</td>
<td>2017 – 2020</td>
</tr>
<tr>
<td>National Council of Teachers of Mathematics</td>
<td>2010 – Present</td>
</tr>
<tr>
<td>Association of Mathematics Teacher Educators</td>
<td>2017 – 2018</td>
</tr>
<tr>
<td>Psychology of Mathematics Education – North American Chapter</td>
<td>2016 – 2018</td>
</tr>
</tbody>
</table>