Mathematics Enrichment through Accelerated Learning to improve Learning and Achievement for PreK-12 students in Alabama

by

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Abstract

The most recent nationwide math scores for 13-year-olds in the US dropping to the lowest level in decades, including Alabama's placement at the bottom, as revealed by the 2019 nationwide NAEP assessment, highlight the urgent need to improve mathematics standards in Alabama and all states. The shortage of math teachers, absenteeism and the lingering effect of the pandemic have been identified as the primary contributing factors to the decline, significantly impacting PreK-12th grade students. Pre-pandemic, mathematics has consistently posed challenges for students in the US educational system. The pandemic has further exacerbated these difficulties, with underrepresented groups and under-resourced schools experiencing the greatest struggles. The resulting "unfinished learning" from past years has alarming implications, as today's students may face earning $49,000 to $61,000 less over their lifetimes, ultimately costing the US economy $128 billion to $188 billion annually, due to their lack of essential skills, behaviors, and mindsets required for workplace success. Research has shown that underrepresented populations have shown a strong affinity for computer devices. This research adopts a quantitative method and focuses on providing support for "accelerated learning" in the state of Alabama. To address these challenges, an online math learning framework called the Learning Explorations Accelerated Program (LEAP) was developed. The LEAP framework aligns with the "2019 Alabama Course of Study: Mathematics," which sets rigorous expectations for all students while incorporating revisions aimed at effectively meeting the requirements of both students and teachers in Alabama's

public schools. Notably, the LEAP framework can be easily adapted to align with other state standards and the Common Core State Standards.

By implementing the LEAP framework, which promotes accelerated learning, this dissertation seeks to enhance students' mathematical proficiency, bridge learning gaps, and equip them with the necessary skills to succeed academically and in future workplaces. The study aims to contribute to the field of mathematics education, providing insights and recommendations for educators, policymakers, and stakeholders to effectively address the challenges faced in mathematics instruction and support the holistic development of Alabama's students.

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List of Abbreviations

ALCoSM – Alabama’s Course of Study: Mathematics

CC – Common Core State Standards

LEAP - Learning Explorations Accelerated Program

NAEP – National Assessment of Educational Progress a.k.a The Nation’s Report Card

NCES – National Center for Education Statistics

NSB – National Science Board

NSF – National Science Foundation

STEM – Science, Technology, Engineering, and Mathematics

Chapter 1 Introduction

1.1 Motivation – Providing Mathematics Learning and Achievement for all Students.

The more opportunities students have to learn mathematics content, the greater their chances of achieving success in mathematics [1]. This means that providing students with adequate and meaningful opportunities to engage with mathematics concepts, theories, and skills play a crucial role in determining the level of achievement students can reach in mathematics; most importantly, tackling math anxiety faced by students [2]. Math provides numerous real-life benefits, including expanding job opportunities, particularly in STEM fields, which can help your child achieve their career goals. It also enhances money management skills, enabling more efficient savings and better enjoyment of life's pleasures through understanding concepts like interest and budgeting. Moreover, math fosters computational skills essential in fields such as computer science, robotics, and engineering. Additionally, it hones problem-solving abilities, empowering students to think critically and make sound decisions by using logic and reasoning [3].

Factors that contribute to the extent of students' opportunities to learn mathematics content may include the curriculum design, instructional methods used by teachers, availability of resources and materials, access to technology, teacher-student interactions, and the overall learning environment. By enhancing and maximizing these opportunities, educators can help all students develop a deeper understanding of mathematical concepts and improve their mathematics achievement.

Tag Cloud on Institute of Education Sciences (IES) shows COVID19, Education Technology, K-12 Education among top priority [4]. Various learning theories, including Piagetian theories, behaviorism, and cognitive psychology, have played prominent roles in shaping educational practices. However, constructivism has emerged as an alternative paradigm that carries profound and meaningful implications for mathematics education [5]. Piaget's theory of developmental constructivism states that children play an active role in constructing knowledge by interacting with their environment. It emphasizes that children are not passive learners, but rather engage in cognitive processes to understand the world around them. When it comes to learning and achieving in mathematics, Piaget's theory suggests that children develop mathematical concepts and reasoning through their own experiences and active exploration. This theory underscores the significance of hands-on learning, problem-solving, and the step-by-step construction of mathematical knowledge. Although there is strong evidence supporting the beneficial effects of Early Childhood Mathematics Education (ECME), its practical implementation remains limited [6]. This is because several early childhood educators do not possess the essential training and support required to offer children from low-income communities the high-quality math learning experiences they need, thereby hindering their academic achievements [7].

The long-term NAEP trend assessment compares student scores to pre-pandemic levels in 2019-2020. During the 2022-23 school year, the NAEP long-term trend (LTT) reading and mathematics assessments were conducted by the National Center for Education Statistics (NCES) on over 8,000 13-year-old students. The results showed a decline in average scores compared to the previous assessment in the 2019-20 school year, with a 4-point decrease in reading and a 9-point decrease in mathematics [8]. In comparison to scores from a decade ago, there was a 7-point decline in reading and a 14-point decline in mathematics. Not since 1990 have 13-year-olds demonstrated math performance at such a low level. There was a decline in both math and reading scores across various percentile groups: 10th, 25th, 50th, 75th, and 90th, representing students with lower, middle, and higher performance levels. Math scores decreased among students in all regions of the country and in almost all student subgroups. Notably, American Indian/Native and Black students experienced the most substantial changes in math scores, with a decrease of 20 points and 13 points, respectively. There also exists a persistent achievement gap persists between students with and without disabilities [9] and English language Learners (ELs) and English-speaking peers [10]. Absence from school was a significant concern, with the percentage of students who missed school five or more times in a month doubling since 2020. This effect of unfinished learning is mostly caused by the pandemic; summer learning loss is another problem and results show that 8^{th} graders are not really ready for high school since they are unable to attain even the fundamental level of math achievement. The 13-year-olds (8th graders) where 10-year-olds (5th graders) when the pandemic hit the US in March 2020 (2019-2020 school year) [11].

Table 1: School year and grade levels of students between 2019 and 2023.

School Year	Age of students	Grade
2019 – 2020	10 years	5^{th} grade
2020 – 2021	11 years	6^{th} grade
2021 – 2022	12 years	7^{th} grade
2022 – 2023	13 years	8^{th} grade

Table 2: National average math levels among some South-East states

Below National Average? (Math)	2011		2013		2015		2017		2019		2022	
Grades States	4^{th}	8^{th}	4^{th}	8^{th}	4^{th}	8^{th}	4^{th}	8^{th}	4^{th}	8^{th}	4^{th}	8^{th}
AL	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
GA	Y	Y	-	Y	Y	-	Y	-	Y	-	-	-
TN	Y	Y	-	Y	Y	-	Y	Y	-	-	-	-
MS	Y	Y	Y	Y	Y	Y	Y	Y	-	Y	-	Y
LA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-	Y
FL	-	Y	-	Y	-	Y	-	Y	-	-	-	-
DoDEA	27	18	17	7	5	5	3	4	1	2	1	1
MA	1	1	2	1	1	1	1	1	3	1	3	2

“Y” means Yes. “-“ means NOT below national average.

Source: The Nation’s Report Card

From the table above, AL remains the only state that is below the national average in mathematics for 4th and 8th grades from 2011 to 2022.

In 2022, the percentage of students in DoDEA who performed at or above NAEP Proficient was 50 percent. This was greater than that for the nation's public schools (32 percent) [12].

Department of Defense Education Activity (DoDEA) claims to exhibit several factors towards the success of the school system. One key driver is sharpened focus on the academic, health, and social and emotional needs of the students. DoDEA also use Standards for Mathematical Practice (SMPs) [12]. The mathematics instructional progression is based on the DoDEA College and Career Ready Standards for Mathematics (CCRSM). The program uses a backwards design model curriculum structured with inquiry: what is it that our students must know and to be able to do at each grade level? The idea is to focus on what students should know, do, and understand by the end of the course, and then align the assessment and instruction accordingly. Backward design helps faculty avoid the common pitfalls of covering too much content, teaching to the test, or using mismatched methods [13].

The complexity and creative nature of learning experience design make design thinking particularly crucial in STEM education. Its focus on fostering connections between STEM disciplines and enhancing STEM workforce readiness is of great significance [14]. The shift in perspective regarding STEM professions and the preference for student-centered project-based learning aligns well with a design thinking model known as outcome-based backward design. In contrast to traditional instructional design, which emphasizes inputs such as textbooks, lessons, and activities, an alternative approach suggests deriving the means of instruction from desired results. Instead of starting with teaching methods, learning designers are encouraged to first consider learning outcomes. A three-stage backward design framework has been proposed, involving the identification of desired results, determination of acceptable evidence for assessment, and planning of learning experiences and instruction. [15] [16].

The State Board of Education in Alabama made the decision to approve new math standards with the objective of addressing the state's underperforming math scores. The newly implemented math standards are designed to establish clear learning objectives for each grade level, which includes additional high school courses. The "2019 Alabama Course of Study: Mathematics" establishes rigorous expectations for all students and incorporates revisions aimed at effectively addressing the requirements of both students and teachers in Alabama’s public schools. Educators, along with business and community leaders, collaborated to develop this course of study with the intention of establishing a solid framework for the development of exemplary mathematics programs throughout the state. By delivering instruction aligned with the guidelines outlined in this document, all students in Alabama will have the opportunity to acquire a strong foundation in mathematics and graduate with comprehensive mathematical proficiency [17].

1.2 Purpose of the Study

To accelerate mathematics learning in the state of Alabama and other states in the US. The evaluation of the effectiveness of online learning tools in improving PreK-12 mathematics education in AL public schools will be investigated. Mathematics is a subject that builds upon previous knowledge. Each concept serves as a stepping stone for subsequent ones and having a solid understanding of the basics is crucial for future success. When students lack a strong foundation, comprehending more advanced concepts becomes increasingly challenging [18].

Mathematics serves as the fundamental basis for all scientific and technological progress [19]. Thus, this will enable students venture into STEM fields in the US colleges and Universities. STEM (Science, Technology, Engineering, and Mathematics) fields have been growing in popularity in recent years. Many educational institutions and governments worldwide have recognized the importance of STEM education and have been actively promoting it. Consequently, there has been an increased emphasis on encouraging students to pursue STEM-related careers. In the past, there has been a significant push to increase enrollment in STEM fields to meet the growing demand for professionals in these areas. Efforts have been made to engage more underrepresented groups, such as women and minorities, in STEM education and careers to promote diversity and inclusivity.

The decline in college enrollment worsened during the 2023 spring semester. The most prevalent undergraduate majors among students in both four-year and two-year colleges remain business, healthcare, and liberal arts [20].

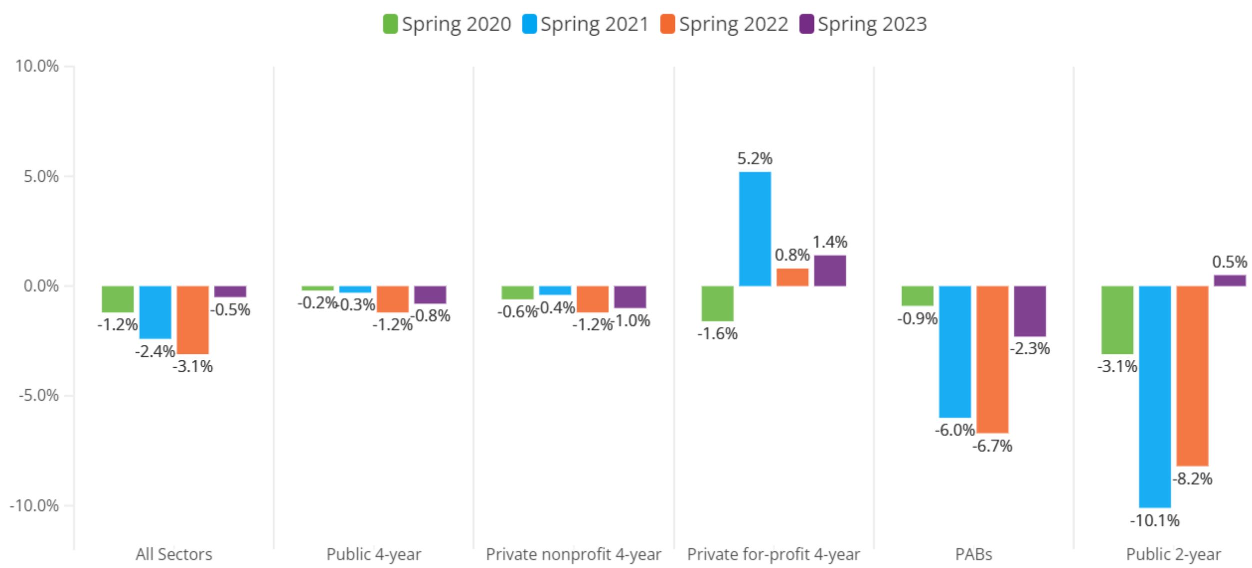


Figure 1: Percent Change in Enrollment from previous year by Institutional sector: 2019 - 2023

In comparison to spring 2021, undergraduate enrollment experienced a significant decrease of over 662,000 students, accounting for a decline of 4.7% [21]. This brings the total decline in undergraduate enrollment, which aligns roughly with the duration of the Covid-19 pandemic, to 1.4 million students, reflecting a decrease of 9.4%. Notably, this decline was more severe than the 3.1% decrease observed in undergraduate numbers during the previous fall [20]. The entire higher education system in the United States was impacted by the COVID-19 pandemic. Based on the available evidence, it is clear that the pandemic has posed financial challenges for certain institutions and disrupted the educational plans of numerous students, particularly women and primary caregivers, underrepresented minorities, and students from low-income families. Among the various types of institutions, community colleges have been hit hardest by declining enrollment, with males experiencing the most substantial decreases [22].

1.3 Dissertation Goals

1. Mitigate learning loss/unfinished learning in PreK-12 education in AL

    a. Creating a framework that teaches mathematics to PreK-12 students.

2. Accelerate Mathematics

    a. Accelerated mathematics refers to a specialized educational program or curriculum that provides an expedited or advanced approach to teaching mathematics. It is designed to offer an accelerated pace of learning, covering more advanced concepts or topics within a shorter timeframe compared to standard mathematics courses. Accelerated mathematics programs are typically intended for students who have demonstrated exceptional aptitude and proficiency in mathematics, allowing them to progress at a faster rate or delve deeper into more complex mathematical concepts. These programs often provide opportunities for students to engage in challenging problem-solving, critical thinking, and abstract reasoning, preparing them for advanced math courses or future academic pursuits in mathematics or related fields.

    b. Use AL state standards “2019 Alabama Course of Study: Mathematics”. When crafting a subject curriculum, school systems have the flexibility to incorporate supplementary content standards that align with their local philosophies, as well as include implementation guidelines, resources, and activities that go beyond the scope of the provided document.

3. Investigate Teacher Self-Efficacy (TSE), enhance formal and informal learning.

1.4 Research Problem

It is not surprising that mathematics is often regarded as one of the most challenging subjects for students [23]. According to recent surveys, 37% of teenagers aged 13 to 17 consider math to be more difficult than other subjects, making it the top-ranked subject in terms of difficulty [24]. A recent study shows that on average, test scores for 13-year-olds (8th grade) continue to decline which was greatly caused by extended school closures during the pandemic period [25].

Absenteeism was also a major concern [26] as the percentage of students that missed school 5 or more times in a month doubled since 2020; soon their poor academic performance leads to a loss of interest in learning [27]. Students who have had difficult math experiences in the past may feel their anxiety rise simply by walking into the classroom [28]. Mathematics requires employing numerous multi-step processes to solve problems, and achieving mastery in this subject demands significantly more practice compared to other subjects [29]. Students who are English learners and those with learning disabilities (LD) require a curriculum design which entails a) explicit instruction; b) student verbalization of their mathematical reasoning; c) visual representations; d) range and sequence of examples; e) multiple and heuristic strategies; f) giving teachers ongoing formative assessment data and feedback on student' mathematics performance; g) providing data and feedback to LD and EL students on their mathematics performance [30].

The long-term NAEP trend assessment compares student scores to pre-pandemic levels in 2019-2020. During the 2022-23 school year, the NAEP long-term trend (LTT) reading and mathematics assessments were conducted by the National Center for Education Statistics (NCES) for 13-year-old students. The results showed a decline in average scores compared to the previous assessment in the 2019-20 school year, with a 4-point decrease in reading and a 9-point decrease in mathematics. In comparison to scores from a decade ago, there was a 7-point decline in reading and a 14-point decline in mathematics. Not since 1990 have 13-year-olds demonstrated math performance at such a low level. There was a decline in both math and reading scores across various percentile groups: 10th, 25th, 50th, 75th, and 90th, representing students with lower (10^{th} and 25^{th}), middle, and higher (75^{th} and 90^{th}) performance levels. Math scores decreased among students in all regions of the country and in almost all student subgroups. Notably, American Indian/Native and Black students experienced the most substantial changes in math scores, with a decrease of 20 points and 13 points, respectively. All these are the effect of unfinished learning caused by the pandemic [8].

Over 8,000 students were tested. NAEP (Nation’s Report Card) shows down by 9 points from last results. Students’ scores were effected by the pandemic. Summer learning loss was another problem. Keeping learning fun and engaging helps. Mississippi “miracle” shift from lowest to 21^{st} was made possible by focusing on teaching style. Unfortunately, students are no longer engaged in learning and results show that 8^{th} graders are not ready for high school. Approximately 3.5 million high school seniors are gearing up for graduation, though, on average, are less ready for college and professional life. They'll be joining the ranks of over 10 million students who have graduated amidst the challenges of the pandemic [31].

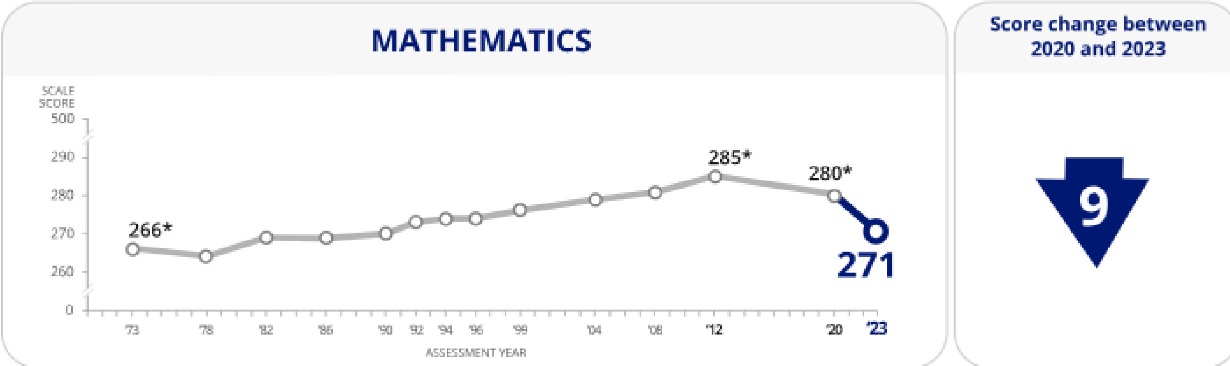


Figure 2: Average scores for 13-year-olds in mathematics from 1971 to 2023 school years

1.5 Research Questions

This research aims to answer these questions as they pertain to the dissertation goals:

RQ1: Is LEAP perceived as easy to use?

RQ2: Is LEAP easy to use?

RQ3: Does LEAP have an ease of learning?

RQ4: Does LEAP provide satisfaction?

RQ5: Does LEAP help students accelerate their learning?

1.6 Research Methodology and Approach

This research uses User-Centered Design (UCD) which has 4 stages: a) analysis; b) implementation; c) testing; d) evaluation. To effectively carry out our research we have two studies. The first is with pre-service teachers who are education students at Auburn University. The second is with in-service teachers all around the United States.

1.7 Organization of the Dissertation

The following chapters are organized as follows: Chapter 2 provides a review of the literature on AL school system, Teacher Self-Efficacy, impact of the pandemic on education, analysis of the 2022 NAEP mathematics assessment results, accelerated learning and UX/UI design considerations. Chapter 3 describes the method for the informant design and the results are discussed in Chapter 4. Chapter 5 dives into the building of LEAP application and the standards incorporated into the development of the framework. In Chapter 6, the usability evaluation method is outlined and report findings from the usability experiment are presented. Chapter 7 presents conclusion and future work.

Chapter 2 Literature Review

2.1 Overview of Alabama PreK-12 School System

2.1.1 Overview of Mathematics Education in AL

Alabama is the #24 largest school system in the United States, serving 740,387 students across the 1,473 public schools for the 2021 school year. Comparing with Massachusetts which seems to consistently excel in education, below are the two state's rankings according to US News and World Report:

AL is: *#43 in PreK – 12*

#44 in Education

#46 in NAEP Math scores

MA is: *#2 in PreK – 12*

#3 in Education

#1 in NAEP Math scores

MA is doing very well in education due to several factors which include the mathematics framework. MA does not use Common Core. They use Massachusetts Curriculum Framework for Mathematics with latest revisions being made in 2017. MA covers PreK-12 while AL covers K-12. MA and AL both use the Standards for Mathematical Practice by the National Council of Teachers of Mathematics (NCTM). Let us compare their 2017 framework with that of 2019 AL.

Progression of Pre-K–8 Domains										
Domain	**Grade Level**									
	PK	**K**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Counting and Cardinality	■	■								
Operations and Algebraic Thinking	■	■	■	■	■	■	■			
Number and Operations in Base Ten		■	■	■	■	■	■			
Number and Operations – Fractions					■	■	■			
The Number System								■	■	■
Ratios and Proportional Relationships								■	■	
Expressions and Equations								■	■	■
Functions										■
Measurement and Data	■	■	■	■	■	■	■			
Geometry	■	■	■	■	■	■	■	■	■	■
Statistics and Probability								■	■	■

Figure 3: 2017 Massachusetts Mathematics Framework

Table 3: Revisions to the 2010 MA Standards

Pre-Kindergarten and Kindergarten		
2010 Standard	**2017 Standard** **Revisions are in red text**	**Rationale for Revision**
PK.CC.4 Count many kinds of concrete objects and actions up to ten, using one-to-one correspondence, and accurately count as many as seven things in a scattered configuration.	Count many kinds of concrete objects and actions up to ten, using one-to-one correspondence, and accurately count as many as seven things in a scattered configuration. Recognize the "one more", "one less" patterns.	Edited to highlight that recognizing patterns in numbers is key to mathematics and fundamental for algebraic thinking.
K.CC.4.c Understand the relationship between numbers and quantities; connect counting to cardinality. c. Understand that each successive number name refers to a quantity that is one larger.	Understand the relationship between numbers and quantities; connect counting to cardinality. c. Understand that each successive number name refers to a quantity that is one larger. Recognize the one more pattern of counting using objects.	Edited to highlight that recognizing patterns in numbers is key to mathematics and fundamental for algebraic thinking.
K.CC.6 Identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group, e.g., by using matching and counting strategies.	Identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group for groups with up to 10 objects, e.g., by using matching and counting strategies.	Edited to incorporate an accompanying footnote into the original standard to clarify student learning expectations for comparing number of objects in kindergarten.
K.OA.5 Fluently add and subtract within 5.	Fluently add and subtract within 5 including zero.	Edited to include zero as a student learning expectations for fluency in kindergarten.
K.MD.3 Classify objects into given categories; count the numbers of objects in each category and sort the categories by count.	Classify objects into given categories; count the numbers of objects in each category (up to and including 10) and sort the categories by count.	Edited to incorporate an accompanying footnote into the original standard to clarify student learning expectations for sorting by count in kindergarten.

Comparing 2017 MA standards with 2019 AL Standards (ALCoSM), they are similar; the revisions on the 2017 standards are included in AL's 2019 standards.

MA and AL have the same mapping between content areas from Kindergarten to 8th grade. For example, a 2nd grade in MA will be taught 1) Operations and Algebraic Thinking before 2) Number and Operations in Base 10. The same applies in AL for the same grade level.

In fourth-grade classrooms with high-performing students, teachers prioritize measurement, geometry, and algebra as focal areas of instruction [32].

Major changes on ALCoSM are in middle and high school math. These changes were made to address the state's bottom ranking on the nationwide mathematics assessment. Prior to ALCoSM, students took Algebra in 9th grade and Geometry in 10th grade [33]. In the current ALCoSM, 9th graders will take Geometry with Data Analysis and in 10th grade will take Algebra I with Probability [17].

2.1.2 Early Childhood Education (ECE) in Alabama

Early childhood is a time of rapid and critical development, and the experiences that children have in their first years of life have a disproportionate influence on their long-term outcomes [34] [35] [36]. "Early childhood care and education (ECCE) aims at the "holistic development of a child's social, emotional, cognitive, and physical needs" which are required "to build a solid and broad foundation for lifelong learning and wellbeing" [37]. ECE is between the ages of 0 – 8 years i.e., about 3rd grade. In 2017-2018 school year [38], elementary schools make up to 68% of the total public schools. According to the National Institute for Early Education Research (NIEER), in 2020, Alabama's First Class Pre-K (FCPK for 4-year old) has been awarded the highest quality rating for the 15th time in a row [39]. The quality standard is determined by 10 criteria: a) Early Learning and Development Standards (ELDS) which states clear and appropriate expectations for learning and development; b) Curriculum supports in language, literacy, mathematics, and social emotional development; c) Teacher degree is a minimum of BA; d) Teacher specialized training in knowledge of learning, development, and pedagogy specific to pre-school children; e) Assistant teacher degree is CDA - Child Development Associate; f) Staff professional development of at least 15 hours of in-service training yearly; g) Maximum class size is 20; h) Staff-Child ratio is 1:10; i) Vision and hearing screenings and referrals; j) Continuous Quality Improvement System (CQIS) which is used to improve the program. AL earned 10 out of 10 on the quality standards benchmark. However, this doesn't necessarily mean that the PreK program is "of high quality" but it is important that all 10 benchmarks are met to show that a state's PreK policies are "fully satisfactory".

2.2 Lingering Problems in Education

In the US, a shutdown in K – 12 schools affected 55.1 million students in 124,000 public and private schools during the 2019 – 2020 academic year [37] with many students experiencing anxiety, fear, insecurity, and inconsistent access to learning, and all these fluctuations causing a deterrent on their mental health and learning [38]. Many educational institutions were forced and unprepared to move from traditional (Face-to-Face) to online teaching [39]. A survey conducted by Barnes & Noble on 432 college students that transitioned to online learning across the U.S shows that 60% of students said they were at least somewhat prepared for the shift [40] but faced a lot of challenges which include technical issues, distractions and time management, staying motivated, understanding course expectations, lack of in-person interaction, adapting to unfamiliar technology, and uncertainty about the future [41]. There were issues with access to computers and the internet, inability for parents and/or guardians to help with homework due to factors such as time, unfamiliarity and language barriers, and the worsening of students' disengagement. Some teachers applied Computational Thinking skills to break down given problems and students were able to learn better remotely [42]. According to UK survey, children from richer families and schools were more likely to continue their education via online learning unlike poorer families/schools. Also, children from richer families spent 30% more time on home learning unlike children from poorer families/schools [43]. According to Microsoft, about 3.3 million of Alabama's 4.9 million residents do not have the minimum broadband speeds needed for video conferencing or streaming at home. In all but six of the state's 67 counties, fewer than 40% of residents have home broadband service [44]. US school enrollment dropped by 2.9 million from 2019 to 2020 [44] and in K-12 education, widened pre-existing disparities in access and technological opportunities [45]. MAP Growth assessments in reading and math for 3-8th grades show that on average, a student in 3rd through 8th grades was 3 to 6 percentile points behind in reading and 8 to 12 percentile points behind in math [45]. Younger students and high-poverty schools faced more academic losses than their counterparts. In elementary grades, Black, Latino and Native Americans performed worse than White and Asian students. Black and Latino students lost 6 months in math, while white students lost 4 months mostly due to "historical inequalities in opportunity and achievement" [46]. Test scores from over 2 million Black, Indigenous, and People of Color (BIPOC) students in 3rd – 8th grades shows that math achievement was significantly impacted in Fall 2020 [45]. African American students lag behind their white counterparts due to poverty and economic resources, physical readiness which is greatly affected by their residential areas, social-emotional, and cognitive readiness, lack of motivation, teacher burn-out, lack of funding and resources [46].

Today's students may earn $49,000 to $61,000 less over their lifetime due to the impact of the COVID-19 pandemic on their education and on entering the workforce in future, could cost the US economy $128 billion to $188 billion every year especially because they lack the skills, behaviors, and mindset to succeed in their workplaces [47]. The pandemic has resulted in "unfinished learning" because students that were promoted to the next grade may be missing the fundamental knowledge needed for achievement and those that repeat a year are less likely to complete high school and advance into college. Research shows that as the Fall 2021-2022 school year begins, there is some "persistent unfinished learning" compared to pre-pandemic historical averages, most especially in early elementary grades for reading and elementary grades for mathematics [48]. A study found out that remote learning caused by the pandemic resulted in significant learning loss academically and socially. More than 97% of educators confirm that they see some learning loss in their students compared with students in previous years; nearly one-third students are expected to repeat a grade [49]. Despite the paradigm shift to remote learning, some students have flourished, and teachers were able to build stronger relationships with students and families [50]. Districts and states need to conduct an in depth and accurate assessment to fully understand the unprecedented impact of the pandemic on learning, which is necessary to set tracks for a successful future [50].

2.2.1 Analysis of the 2022 NAEP Mathematics Assessment Results

The NAEP results for mathematics in 2022 (grades 4 and 8) and 2019 (grade 12) provide insights into the effects of the COVID-19 pandemic on learning disruptions and recovery efforts (grades 4 and 8 only), as well as the learning environment, opportunities, and perspectives of students and educators. A specific COVID-19 module was included in the 2022 NAEP survey questionnaires for grades 4 and 8 to gather information about how students experienced learning and how educators addressed the academic challenges posed by the pandemic. The responses to the NAEP survey questionnaires offer additional information to understand the NAEP performance results. Comparisons of student performance consider factors such as student, teacher, and school characteristics, as well as educational experiences. Various factors, including local educational policies and practices, teacher quality, and available resources, can influence average student achievement. These factors may change over time and differ among student groups [51].

Grade 4

<u>Students' Experiences</u> In 2022, approximately 58% of fourth graders reported learning remotely during the previous school year (2020-2021). Around 20% of fourth graders stated that they did not learn remotely, while 22% could not recall their remote learning status. Among the 58% of fourth graders who remembered learning remotely last school year, a higher proportion of lower-performing students (scoring below the 25th percentile on the mathematics assessment) reported receiving daily or near-daily assistance with their schoolwork compared to their higher-performing counterparts (scoring at or above the 75th percentile). In summary, the lower performing students that learnt remotely last school year had limited access to learning resources.

<u>Teachers' Experiences</u> In 2022, 48% of fourth graders had teachers who reported that students participated exclusively in classroom learning, while 51% had teachers who reported a

combination of classroom and remote learning. Only 1% had teachers who reported students engaging in remote learning exclusively during the current school year. There were 87% of students whose teachers were "quite" or "extremely confident" in their ability to teach fourth-grade students but only 47% of students had teachers who were "quite" or "extremely confident" in their ability to address unfinished learning due to the COVID-19 pandemic. The major difficulties teachers experience are 1) helping students in distance learning and 2) addressing unfinished learning. In AL, 42% of students had teachers that used remedial measures to reduce gaps between knowledge and standards once or twice/week and 37% had teachers that used remedial measures every day or almost. In MA, 38% of students had teachers that used remedial measures to reduce gaps between knowledge and standards once or twice/week and 31% had teachers that used remedial measures every day or almost every day.

		Not applicable		Never		Once or twice/month		Once or twice/week		Every day or almost	
Year	Jurisdiction	Average scale score	Percentage	Average scale score	Percentage	Average scale score	Percentage	Average scale score	Percentage	Average scale score	Percentage
2022	National	240	4	243	5	238	22	236	36	234	33
	National public	237	3	238	4	236	21	235	38	233	35
	Large city	229	2	235	4	229	21	226	38	226	35
	Alabama	‡	1	‡	2	226	18	233	42	230	37
	Massachusetts	241	5	243	6	247	20	243	38	239	31

Figure 4: Showing How often: Remedial measures to reduce gaps between knowledge and standards

Grade 8

<u>Students' Experiences</u> In 2022, approximately 73% of eight graders reported learning remotely, 18% did not learn remotely, while 9% could not recall their remote learning status during the last

school year (2020-2021). Among the 73% of eight graders who remembered learning remotely last school year, a higher proportion of lower-performing students (scoring below the 25th percentile) reported receiving daily or near-daily assistance with their schoolwork compared to their higher-performing counterparts (scoring at or above the 75th percentile). In summary, the lower performing students that learnt remotely last school year had limited access to learning resources; same as fourth graders.

Teachers' Experiences In 2022, approximately 49% of eight graders had teachers who reported that students participated entirely in classroom learning, while 50% had teachers who reported a combination of classroom and remote learning. Only 1% had teachers who reported students engaging in remote learning entirely during the school year. There were 92% of students whose teachers "probably" or "definitely can" conduct a live lesson with students; 88% of students had teachers who were "quite" or "extremely confident" in their ability to teach eight-grade students but only 49% of students had teachers who were "quite" or "extremely confident" in their ability to address unfinished learning due to the COVID-19 pandemic. The major difficulties teachers experience are 1) helping students in distance learning and 2) addressing unfinished learning; same as fourth graders. In AL, 51% of students had teachers that used remedial measures to reduce gaps between knowledge and standards once or twice/week and 17% had teachers that used remedial measures every day or almost every day. In MA, 37% of students had teachers that used remedial measures to reduce gaps between knowledge and standards once or twice/week and 10% had teachers that used remedial measures every day or almost every day.

2.3 Accelerated Learning as a Strategy to Mitigate Learning Loss

2.3.1 Accelerated Academies

A new study suggests that Accelerated Academies is a promising strategy for tackling unfinished learning due to the pandemic's school closures but Black and Latino, and students in high-poverty schools may have less access to the approach [52]. Remediation which involves teaching contents better suited for earlier grades by going back to cover contents that haven't been mastered from a previous grade is not the best approach to handle the situation and might compound the problem [53]. On the other hand, acceleration involves engaging students with the grade-level contents and revisiting previous grade coursework that are necessary to understand the new content. A recent study by Zearn [54] shows that acceleration is more effective than remediation especially for underrepresented students and those from low-income families [54]. In a brief provided by EdResearch for Recovery aimed at providing K-12 educators, strategies to continue education during and after the COVID-19 pandemic, evidence suggest that "although most students will experience some learning loss, the majority will still be able to engage with grade-level content". Some of the insights with regards to learning loss include (i) Students in early grades are more affected and need "intensive recovery needs"; (ii) Supportive schools and strong teacher-student relationships are beneficial; (iii) High-dosage tutoring directly linked to classroom content can significantly accelerate learning in math and reading; (iv) Extended learning time and highly proficient teachers are effective; (v) Robust systems to "monitor for early student warning signs paired with strong norms and routines help students recover emotionally and engage academically" [55].

2.3.2 Spacing Effect

Spacing Effect is one of the oldest studies behind forgetting and retention [56]. Herman Ebbinghaus laid the basis for spaced repetition in the mid-80's and this theory is being implemented in diverse forms of learning [57]. This demonstrates that the long-term memory is enhanced when learning is spaced out instead of "cramming before an exam" [58]. A study on elementary school children shows that this spacing effect learning phenomenon resulted in higher performance for simple and complex concepts [59]. A meta-study by University of Florida in 2003 [60] and another meta-study by York University, Canada in 2015 [61] both suggest that spaced review is a robust and effective strategy that should be adapted to classroom practice. Spacing effect is proven to provide more opportunities to practice learning, both consciously and unconsciously [58]. One method this author has used is by introducing a topic in week one and then reintroducing it later in the semester. Students can review prior materials while applying them in learning new concepts.

2.3.3 Working Memory

Working Memory is the active part of the human processing system [61] and is extensively involved in goal-directed behaviors [62]. Age, emotions, caffeine, and hormones have effects on the working memory at the neurobiological level [62]. Working memory is responsible for the information that must be retained and manipulated to ensure successful task execution [63]. Many of the skills children rely on to learn in school like reading comprehension, arithmetic calculations, comparisons are manipulated in the working memory [64]. However, 10% of school children have poor working memory usually exhibited by skipping important steps, unnecessary repetitions, distractible behavior [65] and having short attention spans [66]. Over 80% of children with low working memory face challenges in reading and mathematics, make poor academic progress and are not usually considered for special education needs [65]. Working memory training and classroom interventions are approaches to alleviating some of these problems with working memory [65].

2.3.4 Teacher Development and Self-Efficacy

Teachers' quality and teachers' professional development have become central concerns in national education policies (Snoek et al., 2019) (Figure 1)

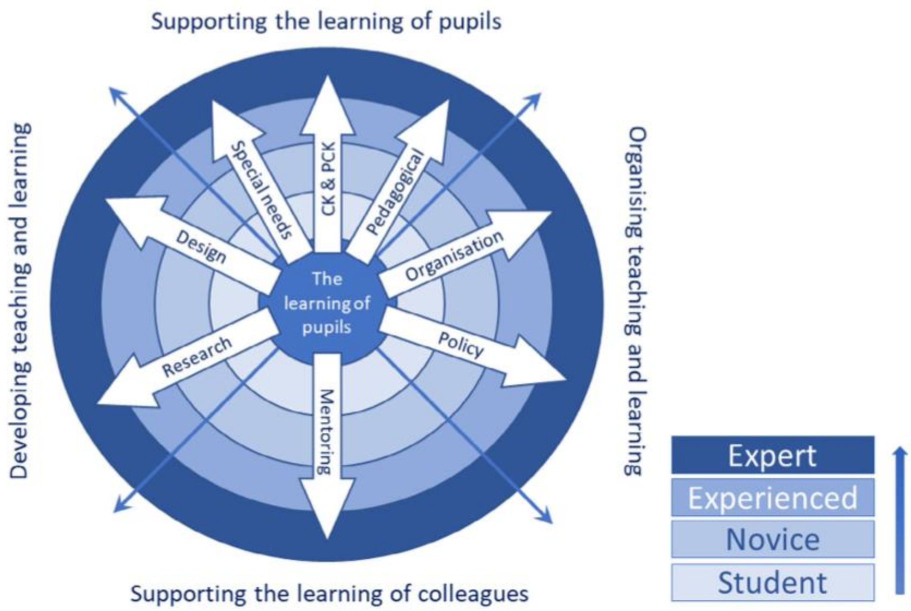


Figure 5: Opportunities for teacher development and teacher careers

Research consistently shows that teacher self-efficacy has a positive relationship with student achievement (Ashton & Webb, 1986). Teacher self-efficacy refers to a teacher's belief in their ability to effectively teach and influence student engagement and learning, even among those who may be difficult or unmotivated. This concept, grounded in Bandura's social cognitive theory, is critical for educators as it can significantly impact their teaching practices, attitudes towards students, and ultimately, student outcomes. In the context of PreK-12 mathematics education, especially post-pandemic, teacher self-efficacy has taken center stage as educators strive to address and close the learning gaps that have emerged or widened during the period of remote and hybrid learning.

Bandura (1977) defines self-efficacy as the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations. In educational settings, teacher self-efficacy affects teachers' beliefs about their abilities to teach, manage the classroom, and facilitate children's academic progress. Tschannen-Moran and Hoy (2001) have further articulated this within the teaching context, suggesting that a strong sense of efficacy can enhance teachers' persistence and willingness to try new teaching approaches, which is particularly important in the ever-evolving landscape of mathematics education. Several factors influence teacher self-efficacy, including mastery experiences, vicarious experiences, verbal persuasion, and physiological and emotional states. Post-pandemic, the need for adaptability and resilience has highlighted the importance of supportive professional communities and ongoing professional development to strengthen teacher self-efficacy.

2.4 Previous Studies (Research Gaps) on Mathematics Enrichment Tools

2.4.1 Khan Academy

The taxonomy of Khan Academy is based on a mastery-based learning model, which is designed to help students master specific skills and concepts at their own pace. The platform offers a hierarchical taxonomy that breaks down the learning content into smaller, more manageable chunks, allowing students to build a strong foundation of knowledge and skills. This aligns with Common Core.

The taxonomy of Khan Academy can be broken down into three levels:

Domain: The top level of the taxonomy is the domain, which represents a broad category of subject matter. Khan Academy offers domains in math, science, economics, humanities, and computer science.

Subdomain: The subdomain represents a narrower category of subject matter within the domain. For example, within the math domain, there are subdomains in algebra, geometry, trigonometry, and calculus.

Topic: The topic is the smallest unit of content within the subdomain and represents a specific skill or concept. For example, within the algebra subdomain, there are topics on linear equations, inequalities, systems of equations, and more.

2.4.2 Mathway

Mathway is an online math problem solver that provides step-by-step solutions to problems in various math subjects, including algebra, geometry, trigonometry, calculus, and more. Here is a breakdown of Mathway's taxonomy:

Subject: The top level of Mathway's taxonomy is the subject, which represents a broad category of math. Mathway offers subjects in algebra, geometry, trigonometry, calculus, statistics, and finite math.

Topic: The topic represents a specific concept or skill within the subject. For example, within the algebra subject, there are topics on solving equations, factoring, graphing, and more.

Level: Within each topic, Mathway offers different levels of difficulty based on the complexity of the problem.

Problem Type: Mathway also breaks down problems by type, such as multiple-choice, short-answer, or word problems.

2.4.3 Chegg Math Solver

Chegg math solver is an EdTech tool that provides step-by-step solutions and explanations on math problems. There are 5 branches (3 algebra and 2 calculus). It covers middle school level (7/8 grades) up to high school level.

2.4.4 StudyPug

StudyPug is an online learning platform that focuses on providing math and science tutorials to students. It focuses on 8^{th} grades and higher. The service typically offers video lessons that are designed to supplement the education that students receive in school.

2.4.5 Math.com

Math.com is an online resource aimed at providing free math lessons, tutorials, and various tools for students, teachers, and parents. It is designed to be a go-to platform for anyone seeking to learn or teach mathematics.

2.4.6 Summary Table

After comparing all the above-mentioned mathematics enrichment tools, there are some gaps we attempt to cover. These include: a) Each grade will have a pathway to sub-content areas; b) At the bottom of each lesson page, there will be a "Test your Knowledge" section to further buttress what the student had just learned from the lessons and is easily accessible by scrolling up; c) The framework is tailored to meet PreK-12th grade students in Alabama because the state standards were used to build the application.

Table 4: Comparing other frameworks with LEAP application

	Khan Academy Math	Mathway	Chegg	StudyPug	Math.com	LEAP
Each grade has pathway to sub-content areas	Y	-	-	Y	-	Y
"Test your knowledge" at bottom page	-	-	-	-	-	Y
Uses AL math standards	-	-	-	-	-	Y

2.5 UX Design for Difference Age Ranges of Children

According to NNGroup, when designing applications for kids, we must remember that their "cognitive abilities to reason, infer, and make connections are still developing" Piaget [148]. Here are the design recommendations:

1. The instructions to achieve a specific goal of a task should be clear and easy to understand. Visual and audio instructions should be short and concise for the kids to understand. For example, an arranged table of toys by color suddenly disarranged and the instruction is to re-arrange them.
2. The instructions should be suitable for the kids' level of understanding. You must ensure that children will understand and be able to make connections between different objects or

characters for the intended age group users. For example, a 5-year-old kid might not be able to play a counting game if they don't understand the connections between pennies, dimes, quarters, and nickels.

3. Use existing mental models about the world. Kids will naturally reference their knowledge base to tackle tasks they are familiar with. For example, in a drawing game, younger kids will tend to use an eraser to recover from a mistake instead of the "redo" and "undo" buttons.

4. Building on the kids' mental models they already acquired in daily life. For example, in a cooking game, a 3-year-old girl could cook a meal by herself. She put a bag of pasta in the pot and knew that the stove must be turned on to cook it.

5. Reduce cognitive load and minimize mental resources. The interfaces should be self-explanatory, and the information needed to interact with the system should be minimal. For example, kids should be able to complete an online task without having to remember series of previous instructions.

6. Support Autocorrection. Sometimes, kids might need to search the web for resources, and they make typographical errors. The autocorrect tool is inevitably necessary for these young minds to enable them to complete their tasks.

7. Instructions should not be too prescriptive. There must be room for alternative controls where necessary. For example, in a coloring game, the instructions specified using a mouse but the kids prefer a touchpad and the task was left incomplete.

8. Using the limited cognitive development in children to design a UI not for kids. This is to curb kids' growing addiction to mobile technology. Parents can set controls to manage their children's screen time with information that are difficult for children to guess or access.

Research shows that a child's physical development of motor skills and coordination determines their ability of interaction with devices.

The table below shows their physical abilities with device interactions.

Table 5: NNGroup designing for kids

		3–5-year-olds	6–8-year-olds	9–12-year-olds
Physical ability	Gross motor skills	Limited	Partially developed	Well developed
	Fine motor skills	Very limited	Limited	Well developed
	Motor coordination	Very limited	Limited	Partially developed
Device preference		Touchscreens	Touchscreens and the trackpad of laptops	Both laptops and touchscreens; can use both the mouse and the trackpad
Gestures mastered at each age		Tapping, swiping, dragging on touchscreens	Clicking with mouse & trackpad, simple keyboard use	Dragging and scrolling with mouse & trackpad, complex coordination between keyboard and mouse

Cool designing for kids – Touchscreen and Desktop:

1. Touchscreen design gestures for kids less than 9 years should be simple such as swiping, tapping, and dragging. Buttons should be large, colorful, and concisely informative. The recommended button size should be at least 2cm x 2cm. A good interface with simple navigation and simple gestures encourages kids to explore its content. Actions should be flexible too; for example, moving an object to a destination can be completed by dragging or tapping. Another important feature is to reduce navigating by recommending similar content on the bottom of the interface instead of clicking the "back" button to return to the previous menu.

2. Desktop-based designs for kids less than 9 years should use clicks. Simple keyboard interactions such as using the arrow keys to move up, down, left, and right can be used too. Dragging, scrolling, and clicking small objects with a mouse or a trackpad are hard for this age group. Those gestures require a relatively high level of fine motor skills; to perform them, kids need to move their wrists and fingers much more precisely than on a touchscreen.

Chapter 3 Method – Informant Design

This chapter describes the method used for carrying out the informant design experiment. There were 2 studies:

Study 1: This was done with pre-service teachers who are Auburn University students.

Study 2: This was carried out by in-service teachers all around the US.

3.1 Purpose

The primary purpose for study 1 is to gain insights from pre-service teachers about: a) The integration of technology in the classroom; b) Teacher Self-Efficacy; c) Effect of COVID in teaching the students; d) Areas in mathematics they think students need reinforcement.

The primary purpose for study 2 was to get insights from in-service teachers about: a) The difficulties they faced teaching during the pandemic; b) Challenges they currently face post-pandemic; c) Areas of math reinforcement for students.

3.2 Research Questions

This research aims to answer these questions as they pertain to the dissertation goals:

RQ1: Is LEAP perceived as easy to use?

To address this question, participants were asked 2 sub-questions:

i) *Perceived ease of use - Learning to operate the system would be easy for me.*

ii) *Perceived ease of use - I would find it easy to get the system to do what I want it to do.*

RQ2: Is LEAP easy to use?

To address this question, participants were asked 3 sub-questions:

i) *Ease of use - It is easy to use.*

ii) *Ease of use - It is simple to use.*

iii) *Ease of use - It is user friendly.*

RQ3: Does LEAP have an ease of learning?

To address this question, participants were asked 2 sub-questions:

i) *Ease of Learning - I learned to use it quickly.*

ii) *Ease of Learning - It is easy to learn to use it.*

RQ4: Does LEAP provide satisfaction?

To address this question, participants were asked 5 sub-questions:

i) *Satisfaction - I am satisfied with it.*

ii) *Satisfaction - I would recommend it to a friend.*

iii) *Satisfaction - It is fun to use.*

iv) *Satisfaction - It works the way I want it to work.*

v) *Satisfaction - It is wonderful.*

RQ5: Does LEAP help students accelerate their learning?

To address this question, participants were asked 2 sub-questions:

i) *Do you think this online framework will help students to accelerate their learning?*

ii) *Can you see yourself utilizing this software in your classroom?*

3.3 Participants

For study 1, a recruitment email containing all IRB documents, research materials and link to a Qualtrics survey was sent out requesting for pre-service teachers for the study. There were 24 Auburn University students from the College of Education that signed up for the study aged 19 – 25 years. All of them were females and have had some teaching experiences at K-12 schools.

For study 2, the participants were in-service teachers all around the United States. Using survey monkey, mathematics teachers were recruited. To ensure that they did teach mathematics at elementary, middle or high school level, the first question asked if they were a mathematics teacher. If they answered "Yes", they would continue with the survey. If they answered "No", they were thanked for participating and exited from the survey. There were 86 people that attempted the survey but only 25 were mathematics teachers and their responses were recorded. The prior years of teaching experience ranged from '0 – 2 years' up to '26 years or more'. There were 20 females and 5 males., The participants were categorized according to the US Census Bureau which comprises 4 regions. There was 1 participant from the West, 17 from the South, 3 from the North-East and 4 from the Mid-West.

3.4 Materials

The materials for the research included: a) Recruitment Email – a request for participation which is completely voluntary; b) Exempt Application; c) Information Letter titled "Participatory Design & Development of Framework supporting Mathematics Acceleration". This comprises 2 phases:

- Phase 1: Informant Design: The 24 AU participants completed an online survey about their opinions and experience with the integration of technology in the classroom, and the effect of COVID in student's learning. The preliminary survey took approximately 10 minutes.
- Phase 2: Application Evaluation: At the end of the preliminary survey, the participants were asked if they wish to be contacted in future for follow-up experiment and task activities, they will be redirected to an online form to type in their email addresses. If they didn't wish to be contacted, they will close the online form to opt out. The online form was created on forms.app. It had only one field to type email address and to confirm the address. Out of the 24 AU students that participated in the informant design, only 7 of them participated in the application evaluation.

The Auburn University Institutional Review Board approved this research to be conducted with PreK – 12th grade teachers. Protocol number is 22-106 EX 2209.

3.5 Task Driven Review of Software Application

A word document containing task activities was included on the survey to enable the participants explore the webpage. The following questions are from 6th Grade Ratios & Proportional Relationships:

a. 4:7 is equivalent to 12:22 True/False __________________
b. A farmer has 20 cows and 30 chickens. What is the ratio of cows to chickens? ______________________
c. The ratio 2:3 is equivalent to: _______________________
   i. 4:3 ii. 4:5 iii. 4:6 iv. 4:7

3.6 Experiment Location

The Informant design experiment was taken at the participant's home. All responses were collected online.

3.7 Instrumentation

The survey collected open-ended and close-ended responses. For study 1, comments were also collected which give insights to the participant's experience as a student and teacher during field work. The section on Teacher Self-Efficacy has three categories:

a. Student Engagement
b. Classroom Management
c. Instructional Strategies

3.8 Measures Adopted

The Teacher Self-Efficacy Scale (TSES) was adopted from Tschannen-Moran and Woolfolk Hoy (2001). There is a long method comprising 24 questions and short method comprising 12 questions. The later method was used and responses are based on a five-point Likert scale (1 = Nothing, 2 = Very Little, 3 = Some Influence, 4 = Quite a Bit, 5 = A great deal). The Post survey is a web-based user interface evaluation which comprises Questionnaire for User Interface Satisfaction (QUIS), Perceived Usefulness and Ease of Use (PUEU), and Usefulness, Satisfaction, and Ease of use (USE).

3.9 Tools for Analysis

The surveys were exported to a CSV file and preprocessed in Excel by coding the data into the suitable formats for analysis. Python was utilized for the predictive analysis.

3.10 Predictive Analysis of Student Reinforcement Needs in Mathematics Using Model Training

The unprecedented circumstances of the COVID-19 pandemic have had a significant impact on education systems worldwide, leading to various challenges for teachers and students alike, especially in the complex domain of mathematics education. This section explores how model training, specifically Logistic Regression using Python and scikit-learn, can be employed to access the impact of various factors that contribute to the challenges teachers face in relation to students needing reinforcement in content areas of mathematics during and after the pandemic.

3.10.1 Part 1: Model Training During COVID-19

<u>Variables and their Impact</u>

During the COVID-19 pandemic, teachers faced an array of obstacles, many of which were new and unique to the situation. The response variables such as lack of engagement, lack of attention, and lack of motivation became prevalent due to remote learning conditions. We will see later that factors such as varying levels of students in the same course, lack of discipline, and lack of parental support compounded the issue, creating a multifaceted problem that teachers had to navigate.

<u>Logistic Regression Analysis</u>

Logistic Regression, a predictive analysis tool, is used to describe data and to explain the relationship between a response binary variable $Y \in \{0, 1\}$, and one or more explanatory variables $X = (X_1, X_2, \dots, X_p)$. X is a p-vector which corresponds to each column on my dataset. Specifically, the Logistic Regression takes the form:

$$P(Y = 1 \mid X) = \frac{e^{X\beta}}{1 + e^{X\beta}} \qquad (1)$$

where $\beta = (\beta_1, \beta_2, \dots, \beta_p)$ are the coefficients to be estimated and they are used to measure the impact of the contribution of each factor estimating the response probabilities using (1) above.

In the context of educational challenges during COVID-19:

- Dependent Variables: The reasons for student reinforcement needs (binary: present or not present).
- Independent Variables: Teachers' prior years of experience, grade level of students they teach, age, gender, household income, and proficiency in 10 different content areas of mathematics: a) Number Properties and Operations; b) Measurement; c) Geometry; d) Data Analysis; e) Algebra; f) Data Analysis, Statistics and Probability; g) Algebra and Functions; h) Operations and Algebraic Thinking; i) Operations with Numbers; j) Foundations of Counting

<u>Implementation with Python and scikit-learn</u>

Using Python's scikit-learn library, a Logistic Regression model was constructed to analyze these relationships. The process is as follows:

1. Data Collection: Data was gathered through surveys that record the variables of interest.
2. Data Preprocessing: Encoding the categorical data, handling missing values, and scaling where necessary.
3. Model Construction: Utilizing Logistic Regression from scikit-learn to construct the model.
4. Training the Model: Fit the model on the data collected from the COVID-19 period.
5. Model Evaluation: Evaluate the model using metrics like accuracy and the confusion matrix.
6. Interpretation: Interpret the model coefficients to understand the impact of each predictor.

Through this model, educators and policymakers could predict which factors were most likely to contribute to the need for reinforcement in specific mathematical content areas.

3.10.2 Part 2: Post COVID-19 Predictive Analysis

Changes in the Educational Landscape

As schools transition back to in-person learning or hybrid models, the challenges faced during the pandemic persist, though their nature may have evolved. Post-COVID-19, the same response variables are considered, but the context in which they influence teaching and learning may have changed.

Ongoing Model Training and Prediction

The Logistic Regression model was updated with post-pandemic data to reflect the changes in educational environments. The steps remain similar to the process during COVID-19, with a few key differences:

1. Data Adaptation: Incorporate new data reflecting post-COVID-19 conditions.
2. Feature Selection: Re-evaluate the predictor variables to ensure they are still relevant and adjust if necessary.
3. Continuous Training: Retrain the model periodically to adapt to the shifting educational landscape.
4. Model Optimization: Fine-tune the model using techniques like cross-validation and hyperparameter tuning to improve its predictive performance.
5. Result Application: Use the predictions to develop targeted interventions for areas where students are predicted to need the most reinforcement.

Leveraging Logistic Regression within Python's scikit-learn framework offers a powerful tool for educators to anticipate and understand the challenges they might face in reinforcing mathematical concepts. During and after COVID-19, such predictive models can enable a more responsive educational system, allowing for tailored support where it is most needed. By continuously refining these models with current data, educators can help mitigate the impacts of the pandemic and any such future disruptions to education.

Chapter 4 Result – Informant Design Experiment

4.1 Participants

In study 1 with the pre-service teachers, all 24 participants were female AU students. There were 10 (42%) that have completed Bachelor's degree, 2 (8%) have completed at least one year of course work beyond a bachelor's degree but not a graduate degree, and 12 (50%) have completed an Associate's degree. There was 1 (4%) participant that taught Kindergarten, 1 (4%) for 1st grade, 9 (38%) for 3rd grade, 10 (42%) for 4th grade, 2 (8%) for 5th grade, and 1 (4%) for 6th grade. There are 79% of the pre-service teachers that teach 3rd and 4th grades. The schools are all located within Auburn City Schools, Opelika City Schools, and Lee County School District.

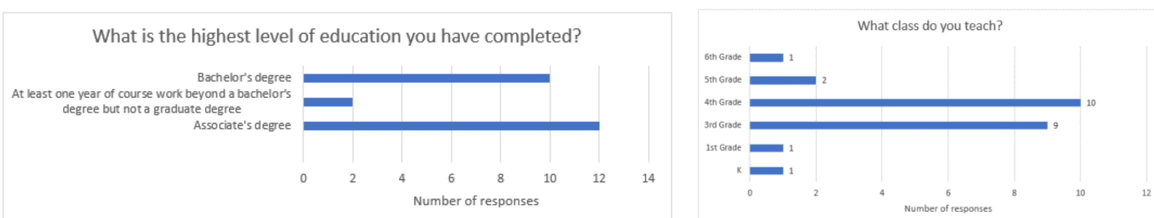


Figure 6: Study 1 Highest level of education and class they teach

In Study 2 with in-service teachers, out of the 25 participants, there were 20 (80%) females and 5 (20%) males. The age ranges are categorized as follows: 5 (20%) are between 19-29 years, 9 (36%) are 30-44 years, 10 (40%) are 45-60 years, 1 (4%) is over 60 years. Their regions according to US Census Bureau shows that 4 (16%) are located in the Mid-West, 3 (12%) in the North-East, 17 (68%) in the South, and 1 (4%) in the West.

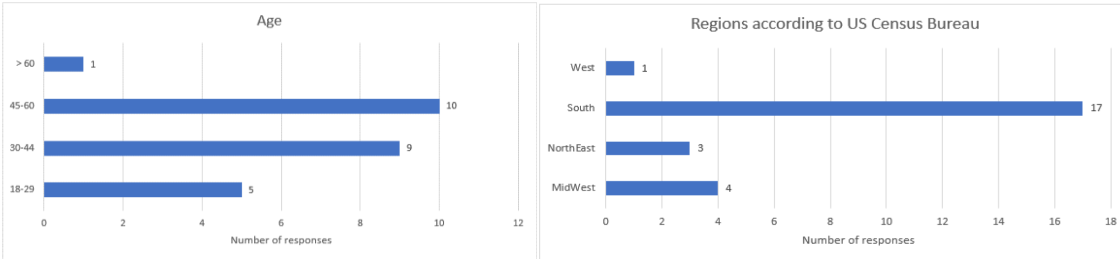


Figure 7: Study 2 Age and Region

Also, the in-service teachers self-reported that 14 (56%) instruct Elementary School, 8 (32%) for Middle School, 3 (12%) for High School. Their prior years of teaching experience are thus: 3 (12%) reported they have been teaching for 0-2 years, 4 (16%) for 3-5 years, 7 (28%) for 6-10 years, 2 (8%) for 11-15 years, 3 (12%) for 16-20 years, 5 (20%) for 21-25 years, and 1 (4%) for 26 years or more.

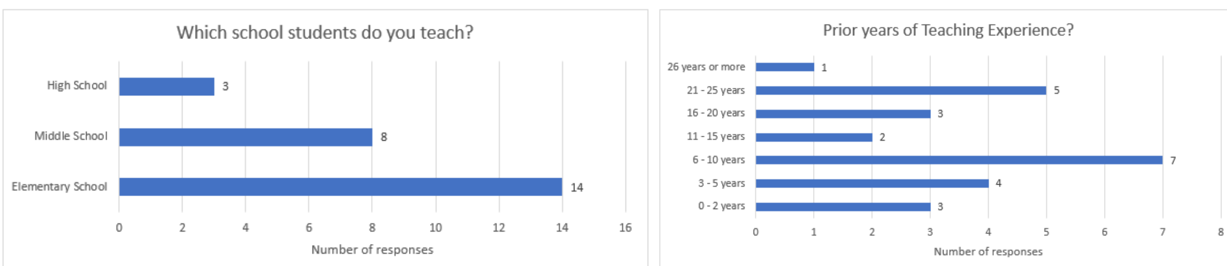


Figure 8: Study 2 school level of students taught and prior years of teaching experience

4.2 Technology Integration

In this section, data was collected from study 1. Questions were asked about the technology they use in the classroom to support student learning. This is a “Check all that apply” inquiry and the participants were allowed to choose more than one response. The top 3 technology tools were Smart Boards 21 (35%), Tablets 18 (30%) and Laptops 12 (20%). The bottom 3 were Desktop Computers 5 (8%), Phones 2 (3%) and TV 2 (3%). The response about how the students use technology show that the top 2 uses are for playing an interactive game 23 (33%) and performing a classroom activity 22 (32%). Also, 15 (63%) of the teachers said that the students spend 1-3 hours in a day and 12 (50%) reported 3-5 hours use in a week. There were 17 (71%) of teachers that use digital assessment technologies and out of them, 13 (54%) said they use “Kahoot”. The following table shows responses on technology integration:

Table 6: Technology Integration

	Do you think technology help students learn a concept faster? – Q1	Do you think technology will help all students think and learn more deeply? – Q2	Do you think that integrating technology into your curriculum is important for student success? – Q3	Do you think the students should use more/less technology tools in the classroom? – Q4	Do you sometimes think that technology in the classroom is a distraction? – Q5
No	2	5	2	8	0
Yes	17	18	22	10	22
Maybe	5	1	0	6	2
Total	24	24	24	24	24

Selected open responses include:

Q1: "I think technology has potential to help students learn concepts quicker, but if used incorrectly, the technology could possibly distract students".

Q2: "Every student is different so technology may make learning more complex for some children when it doesn't need to be".

Q3: There were no open responses for this question. However, 22 (91%) of the pre-service teachers think that integrating technology the curriculum is important for student success.

Q4: "If integrated properly. Technology should support instruction and not replace it".

Q5: There were no open responses for this question. However, 22 (91%) of the pre-service teachers sometimes think that technology in the classroom is a distraction.

In the case of mode of instruction for regular teaching, Teacher-directed whole class was the highest response with 22 (44%) cases while Student-direct small group was the least with 9 (18%) cases for student engagement in learning.

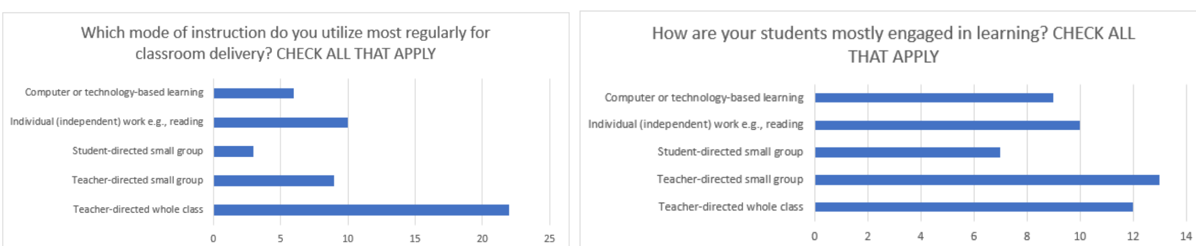


Figure 9: Mode of instruction for teaching and student's preferred mode of learning

4.3 Teacher Self-Efficacy

The Teacher Self-Efficacy results can describe teachers' level of enthusiasm and commitment, their willingness to experiment with new methods to better meet the needs of their students, and their ability to motivate students and manage classroom dynamics.

The Teacher Self-Efficacy Scale (TSES) was adopted from Tschannen-Moran and Woolfolk Hoy (2001). The short method was used. It comprises 12 questions based on a five-point Likert scale (1 = Nothing, 2 = Very Little, 3 = Some Influence, 4 = Quite a Bit, 5 = A great deal). The questions for the three sub-categories are thus grouped with four questions in each category:

- Efficacy in Student Engagement: Questions 2, 3, 4, 11.
- Efficacy in Instructional Strategies: Questions 5, 9, 10, 12.
- Efficacy in Classroom Management: Questions: 1, 6, 7, 8.

Table 7: Teacher Self-Efficacy Scale Results

Teacher Self-Efficacy Scale (TSES)	**Mean**
Efficacy in Student Engagement	**(4.2)**
Q2: How much can you do to motivate students who show low interest in school work?	4.0
Q3: How much can you do to get students to believe they can do well in school work?	4.3
Q4: How much can you do to help your students value learning?	4.3
Q11: How much can you assist families in helping their children do well in school?	4.0
Efficacy in Instructional Strategies	**(4.3)**
Q5: To what extent can you craft good questions for your students?	4.5
Q9: How much can you use a variety of assessment strategies?	4.3
Q10: To what extent can you provide an alternative explanation or example when students are confused?	4.4
Q12: How well can you implement alternative strategies in your classroom?	4.1
Efficacy in Classroom Management	**(4.1)**
Q1: How much can you do to control disruptive behavior in the classroom?	4.2
Q6: How much can you do to get children to follow classroom rules?	4.3
Q7: How much can you do to calm a student who is disruptive or noisy?	3.8
Q8: How well can you establish a classroom management system with each group of students?"	4.2

Efficacy in Student Engagement

From Table x above, the pre-service teachers rate themselves capable to engage their students with a mean rating of 4.2. The lowest rankings are Q2 and Q11 while the highest are Q3 and Q4.

Efficacy in Instructional Strategies

"To what extent can you craft good questions for our students"- Q5 has the highest mean both in this category and in the overall scale. The lowest in this group is Q12.

Efficacy in Classroom Management

This category has the lowest overall ranking in the scale with the lowest being "How much can you do to calm a student who is disruptive or noisy?" – Q7.

4.4 Logistical Regression Prediction Model

This section deals with training a machine learning classification model to predict challenges faced by teachers: a) Part 1: During COVID by in-service teachers; b) Part 2: Post COVID by in-service teachers; c) Part 3: Post COVID by pre-service teachers; based on specific features and math content areas where students need reinforcement. Here's the analysis using Python and scikit-learn:

The model is evaluated using:

1. Accuracy score
2. Confusion matrix

Response variables from our dataset are: 1) Lack of Engagement; 2) Lack of Attendance; 3) Lack of Motivation; 5) Supporting different levels of students in the same course; 6) Lack of Discipline (Home Training); and 7) Lack of Parental Support. They are denoted thus:

Part 1: During COVID by in-service, the columns are: Q5_1, Q5_2, Q5_3, Q5_5, Q5_6, Q5_7

Part 2: Post COVID by in-service, the columns are: Q6_1, Q6_2, Q6_3, Q6_5, Q6_6, Q6_7

Part 3: Post COVID by pre-service, the columns are: Q50_1, Q50_2, Q50_3, Q50_5, Q50_6, Q6_7

In Part 1 and 2, a total of 25 samples/observations and 15 predictor variables were used. “QX” corresponds to the predictor column. Q7_1 to Q7_10 are the 10 content areas in mathematics. All 15 predictors are:

[Q2Prior years of teaching experience, Q4Which school students teaching, Q7_1Number Properties and Operations, Q7_2Measurement, Q7_3Geometry, Q7_4Data Analysis, Q7_5Algebra, Q7_6Data Analysis, Statistics and Probability, Q7_7Algebra and Functions, Q7_8Operations and Algebraic Thinking, Q7_9Operations with Numbers, Q7_10Foundations of Counting, Q8Age, Q10Gender, Q11Household Income]

Below are the predictive results from in-service teachers on the effect of COVID on Mathematics.

4.4.1 Part 1: During COVID with In-service Teachers

Lack of Engagement

In scoring the model, the accuracy score is 0.68 which indicates that the model correctly predicted the outcome for 68% of the samples. Accuracy is the percentage of correct classifications, over the total number of samples.

The confusion matrix provides a breakdown of true positives, false positives, true negatives, and false negatives, allowing for a deeper understanding of where the model might be making mistakes. For Lack of Engagement, the confusion matrix is:

```
[[5    5]
 [3   12]]
```

The confusion matrix is a prediction summary in 2x2 matrix (2 rows and 2 columns) for a binary classification problem. The matrix shows:

Row1 Col1: True Negative (TN) = 5: True cases that were correctly predicted as negative.

Row1 Col2: False Positive (FP) = 5: Negative cases that were incorrectly predicted as positive.

Row2 Col1: False Negative (FN) = 3: Positive cases that were incorrectly predicted as negative.

Row2 Col2: True Positive (TP) = 12: True cases that were correctly predicted as positive.

The correct classifications are sum on the diagonal (5+12) = 17; misclassifications are sum of all numbers not on the diagonal (5+3) = 8. Total = 25.

The fifteen coefficients include:

[[-0.21985661	0.	0.	0.	0.	0.
0.	0.62209839	0.	0.	0.18804267	0.
0.20759916	0.	0.16046687]]			

The coefficients are the "weight" of each predictor variable which provide insights into the relationship between the features and the response variables. If it is zero, it means that there is no effect of the predictor variable on the response variable. Non-zero means it is statistically significant. Positive and negative values show the direction of effect. This means that higher (more positive) coefficients indicate that the particular feature is more associated with the occurrence of the challenges while lower (more negative) coefficients suggest the opposite. Here is the code to initialize a logistic regression model and train it using the feature data 'x' and response variable 'y_covid_1'.

```
log_engage = LogisticRegression(penalty='l1', solver='liblinear', class_weight = 'balanced')
log_engage.fit(x, y_covid_1)
```

To improve the model, L1 (Lasso) regularization penalty was used to prevent overfitting by shrinking the parameters towards zero This encourages feature selection by adding the absolute values of the coefficients to the loss function.

‘liblinear’ solver is suitable for small datasets. The model uses a balanced class weight.

The regularization penalty and class weights are set to control the model's behavior during training.

Below are the coefficients of the features from the trained logistic regression model and have been categorized as having ‘zero statistical significance’, ‘negative significance’ and ‘positive significance’. The highest weights in the positive significance are in bold fonts.

Table 8: In-service During COVID Lack of Engagement

Zero statistical significance	Negative Significance	Positive Significance
• Which school students they teach • Number Properties & Operations • Measurement • Geometry • Data Analysis • Algebra • Algebra and Functions • Operations & Alg. Thinking • Foundations of Counting • Gender	• Prior years of teaching experience (-0.2)	• **Data Analysis, Stat & Probability (0.6)** • Operations with Numbers (0.18) • Age (0.2) • Household Income (0.16)

This shows that students experience lack of engagement in the content area: “Data Analysis, Stat & Probability” more than “Operations with Numbers”. Also, as the age of the teacher and household income increase, the lack of engagement increases, too. This means that older individuals are associated with lack of engagement.

Lack of Attendance

Accuracy: 0.84

The confusion matrix is: [[6 1]
[3 15]]

The correct classifications are sum on the diagonal (6+15) = 21; misclassifications are sum of all numbers not on the diagonal (3+1) = 4. Total = 25.

The coefficients include:

[[0.38037962	0.	0.	-1.26739986	0.	0.
0.	0.	0.	0.	0.35155028	0.30632853
-0.33520656	0.99696902	-0.02856677]]			

Table 9: In-service During COVID Lack of Attendance

Zero statistical significance	Negative Significance	Positive Significance
• Which school students they teach • Number Properties & Operations • Geometry • Data Analysis • Algebra • Data Analysis, Stat & Probability • Algebra and Functions • Operations & Alg. Thinking	• Measurement (-1.26) • Age (-0.33) • Household Income (-0.02)	• Prior years of teaching experience (0.38) • Operations with Numbers (0.35) • Foundations of Counting (0.30) • **Gender (0.99)**

This prediction implies that more years of teaching experience is correlated with lack of attendance. Also, greater emphasis in “Operations with Numbers” and “Foundations of Counting” correlates with increased lack of attendance. A high coefficient of 0.99 with gender coded as 0 for female teachers and 1 for male teachers indicates that male teachers are strongly associated with a higher lack of attendance compared to female teachers. On the other hand, the negative coefficient for “Measurement” is interpreted that people who have problem in measurement tend to not miss class i.e., have better attendance OR people who have problem in measurement tend to attend classes.

Lack of Motivation

Accuracy: 0.64

Confusion matrix: [[5 5]
[4 11]]

The sum of correct classifications is 16; sum of misclassifications is 9. Total = 25.

The coefficients include:

[[-0.0138506	0.	0.280535	-0.06554215	0.	0.
0.	0.	0.	0.	0.1245513	0.
0.02211325	0.	-0.00294471]]			

Table 10: In-service During COVID Lack of Motivation

Zero statistical significance	Negative Significance	Positive Significance
• Which school students they teach • Geometry • Data Analysis • Algebra • Data Analysis, Stat & Probability • Algebra and Functions • Operations & Alg. Thinking • Foundations of Counting • Gender	• Prior years of teaching experience (-0.01) • Measurement (-0.06) • Household Income (-0.002)	• **Number Properties & Operations (0.28)** • Operations with Numbers (0.12) • Age (0.02)

This shows that the content areas "Number Properties & Operations" and "Operations with Numbers" is associated with a higher lack of motivation. Also, students lack motivation when they have older teachers.

Supporting different levels of students in the same course

Accuracy: 0.8

Confusion matrix: [[10 3]
[2 10]]

The sum of correct classifications is 20; sum of misclassifications is 5. Total = 25.

The coefficients include:

[[0.31928091	0.	0.	-0.27463758	0.	0.
-0.5397797	1.4917222	0.24316381	0.	0.	0.
-0.59418075	0.	0.0319606]]			

Table 11: In-service During COVID Supporting different levels of students in the same course

Zero statistical significance	Negative Significance	Positive Significance
• Which school students teaching • Number Properties and Operations • Geometry • Data Analysis • Operations and Algebraic Thinking • Operations with Numbers • Foundations of Counting • Gender	• Measurement (-0.27) • Algebra (-0.53) • Age (-0.59)	• Prior years of teaching experience (0.31) • **Data Analysis, Statistics and Probability (1.49)** • Algebra and Functions (0.24) • Household Income (0.03)

This shows that in a "Data Analysis, Statistics and Probability" course, it is more difficult to support students that need reinforcement than it is in "Algebra and Functions" course.

Lack of Discipline

Accuracy: 0.76

Confusion matrix: [[8 2]
 [4 11]]

The sum of correct classifications is 19; sum of misclassifications is 6. Total = 25.

The coefficients include:

[[0.	0.	0.52221542	0.	0.	0.
0.	0.29494948	0.	1.2436329	0.21527761	0.
0.	0.	-0.13214388]]			

Table 12: In-service During COVID Lack of Discipline

Zero statistical significance	Negative Significance	Positive Significance
• Prior years of teaching experience • Which school students teaching • Measurement • Geometry • Data Analysis • Algebra • Algebra and Functions • Foundations of Counting • Age • Gender	• Household Income (-0.13)	• Number Properties and Operations (0.52) • Data Analysis, Statistics and Probability (0.29) • **Operations and Algebraic Thinking (1.24)** • Operations with Numbers (0.21)

This shows that among all four math courses listed, teaching an "Operations and Algebraic Thinking" course has the strongest correlation with a lack of discipline in the students. It is important to note that correlation does not imply causation because there could be underlying factors or variables not accounted for in the model.

Lack of Parental Support

Accuracy: 0.68

Confusion matrix: [[8 5]
[3 9]]

The sum of correct classifications is 17; sum of misclassifications is 8. Total = 25.

The coefficients include:

0.171187	0.	0.	0.	-0.59034978	0.4058313
0.	0.	0.	-0.34299335	0.2393958	0.32230945
0.	0.	-0.14287257]]			

Table 13: In-service During COVID Lack of Parental Support

Zero statistical significance	Negative Significance	Positive Significance
• Which school students teaching • Number Properties and Operations • Measurement • Algebra • Data Analysis, Statistics and Probability • Algebra and Functions • Age • Gender	• Geometry (-0.59) • Operations and Algebraic Thinking (-0.34) • Household Income (-0.14)	• Prior years of teaching experience (0.17) • **Data Analysis (0.40)** • Operations with Numbers (0.23) • Foundations of Counting (0.32)

This finding suggests that more students lack parental support in a “Data Analysis” course than in “Operations with Numbers (ON)” and “Foundations of Counting (FC)”. Because this is a correlation not causation, further investigation is needed to understand the underlying reasons for this relationship.

4.4.2 Part 2: Post COVID with In-service Teachers

The Post COVID results are also from the same in-service teachers. They give their insights on the challenges they are currently facing in the classroom. Using the predictive model, we want to investigate these challenges to see if there are persistent issues experienced as during COVID. The same approach is used as "During COVID" but the responses are distinct for this collected data.

The model is evaluated using:

1. Accuracy score
2. Confusion matrix

Response variables from our dataset are: 1) Lack of Engagement; 2) Lack of Attendance; 3) Lack of Motivation; 5) Supporting different levels of students in the same course; 6) Lack of Discipline (Home Training); and 7) Lack of Parental Support. They are denoted thus:

Part 2: Post COVID, the columns are: Q6_1, Q6_2, Q6_3, Q6_5, Q6_6, Q6_7

Below are the predictive results from in-service teachers on the post-effect of COVID on Mathematics. The features in the positive significance with the highest weights are in bold fonts.

Lack of Engagement

Accuracy: 0.88

Confusion matrix: [[14 3]
[0 8]]

The sum of correct classifications is 22; sum of misclassifications is 3. Total = 25.

The coefficients include:

[[-0.64136498	0.65299297	1.798631	0.	0.	0.
0.	0.	0.	0.	0.	-0.75210823
0.22026171	0	0.0365456]]			

Table 14: In-service Post COVID Lack of Engagement

Zero statistical significance	Negative Significance	Positive Significance
• Measurement • Geometry • Data Analysis • Algebra • Data Analysis, Statistics and Probability • Algebra and Functions • Operations and Algebraic Thinking • Operations with Numbers • Gender	• Prior years of teaching experience (-0.64) • Foundations of Counting (-0.75)	• Which school students teaching (0.65) • **Number Properties and Operations (1.79)** • Age (0.2) • Household Income (0.03)

This shows that post-COVID, students with older teachers and those in higher grades experience lack of engagement. Though relatively small, higher household income is correlated with a minor increase in lack of engagement. Emphasis on "Number Properties and Operations" course shows a strong correlation with lack of engagement. This could mean that students lose interest or engagement as this course progresses.

Lack of Attendance

Accuracy: 0.8

Confusion matrix: [[11 3]
[2 9]]

The sum of correct classifications is 20; sum of misclassifications is 5. Total = 25.

The coefficients include:

[[-0.19817873	0.	0.	0.	0.	-0.37183452
-0.15266943	0.	0.	0.	0.	0.
-0.35046696	0.75681278	0.47026455]]			

Table 15: In-service Post COVID Lack of Attendance

Zero statistical significance	Negative Significance	Positive Significance
• Which school students teaching • Number Properties and Operations • Measurement • Geometry • Data Analysis, Statistics and Probability • Algebra and Functions • Operations and Algebraic Thinking • Operations with Numbers • Foundations of Counting	• Prior years of teaching experience (-0.19) • Data Analysis (-0.37) • Algebra (-0.15) • Age (-0.35)	• **Gender (0.75)** • Household Income (0.47)

A high coefficient of 0.75 with gender coded as 0 for female teachers and 1 for male teachers indicates that male teachers are strongly associated with a higher lack of attendance compared to female teachers. During COVID, Gender (0.99) was also the highest contributing factor for lack of attendance.

Lack of Motivation

Accuracy: 0.84

Confusion matrix: [[10 2]
[2 11]]

The sum of correct classifications is 21; sum of misclassifications is 4. Total = 25.

The coefficients include:

[[-0.07583125	0.	1.03733426	0.62596302	0.	0.48355828
-0.28883843	0.	0.3771444	0.	0.	0.
0.	0.	-0.16230895			

Table 16: In-service Post COVID Lack of Motivation

Zero statistical significance	Negative Significance	Positive Significance
• Which school students teaching • Geometry • Data Analysis, Statistics and Probability • Operations and Algebraic Thinking • Operations with Numbers • Foundations of Counting • Age • Gender	• Prior years of teaching experience (-0.07) • Algebra (-0.28) • Household Income (-0.16)	• **Number Properties and Operations (1.03)** • Measurement (0.62) • Data Analysis (0.48) • Algebra and Functions (0.37)

This shows that "Number Properties and Operations" is a course where students experience a lack of motivation. During COVID, this was also the highest contributing factor with coefficient 0.28.

Supporting different levels of students in the same course

Accuracy: 0.8

Confusion matrix: [[14 3]
[2 6]]

The sum of correct classifications is 20; sum of misclassifications is 5. Total = 25.

The coefficients include:

[[0.05341888	0.	0.	0.	0.	-0.44802434
0.	0.94047518	0.	0.	0.	0.
-0.43278464	0.	0.16924116			

Table 17: In-service Post COVID Supporting different levels of students in the same course

Zero statistical significance	Negative Significance	Positive Significance
• Which school students teaching • Number Properties and Operations • Measurement • Geometry • Algebra • Algebra and Functions • Operations and Algebraic Thinking • Operations with Numbers • Foundations of Counting • Gender	• Data Analysis (-0.44) • Age (-0.43)	• Prior years of teaching experience (0.05) • **Data Analysis, Statistics and Probability (0.94)** • Household Income (0.16)

Data Analysis, Statistics and Probability is a course where teachers need to support different levels of students both during and post-COVID.

Lack of Discipline

Accuracy: 0.8

Confusion matrix: [[9 3]
[2 11]]

The sum of correct classifications is 20; sum of misclassifications is 5. Total = 25.

The coefficients include:

[[-0.59296643	0.	0.	-0.43609923	0.	0.
0.	-0.25098782	0.	0.146282	0.	1.76899668
0.	0.	0.47941451]]			

Table 18: In-service Post COVID Lack of Discipline

Zero statistical significance	Negative Significance	Positive Significance
• Which school students teaching • Number Properties and Operations • Geometry • Data Analysis • Algebra • Algebra and Functions • Operations with Numbers • Age • Gender	• Prior years of teaching experience (-0.59) • Measurement (-0.43) • Data Analysis, Statistics and Probability (-0.25)	• Operations and Algebraic Thinking (0.14) • **Foundations of Counting (1.76)** • Household Income (0.47)

This shows that "Foundations of Counting" is a content area that in-service teacher think students need reinforcement due to a lack of discipline.

Lack of Parental Support

Accuracy: 0.84

Confusion matrix: [[13 2]
[2 8]]

The sum of correct classifications is 21; sum of misclassifications is 4. Total = 25.

The coefficients include:

[[0.	0.	0.	0.	-0.27248731	0.
0.	-0.04387947	0.	0.	1.4553416	0.60160098
-0.24860655	0.	0]]			

Table 19: In-service Post COVID Lack of Parental Support

Zero statistical significance	Negative Significance	Positive Significance
• Prior years of teaching experience • Which school students teaching • Number Properties and Operations • Measurement • Data Analysis • Algebra • Algebra and Functions • Operations and Algebraic Thinking • Gender • Household Income	• Geometry (-0.27) • Data Analysis, Statistics and Probability (-0.04) • Age (-0.24)	• **Operations with Numbers (1.45)** • Foundations of Counting (0.60)

This shows that "Operations with Numbers" is a content area that in-service teacher think students need reinforcement due to a lack of parental support.

4.4.3 Part 3: Post COVID with Pre-service Teachers

This section presents results gotten from pre-service teachers about challenges they are currently facing in the classroom with regards to teaching their students. Using the predictive model, we want to investigate these challenges to detect if there are similarities with those experienced by in-service teachers "Post COVID".

The model is evaluated using:

1. Accuracy score
2. Confusion matrix

Response variables from our dataset are: 1) Lack of Engagement; 2) Lack of Attendance; 3) Lack of Motivation; 5) Supporting different levels of students in the same course; 6) Lack of Discipline (Home Training); and 7) Lack of Parental Support. They are denoted thus:

Part 3: Post COVID by pre-service, the columns are: Q50_1, Q50_2, Q50_3, Q50_5, Q50_6, Q6_7

In Part 3, a total of 24 samples/observations and 52 predictor variables were used. "QX" is the Question column which corresponds to the predictor column in the dataset. All 52 predictors have been numbered sequentially from 1 – 52. Numbers 3 to 5 are technology tools teachers use in the classroom to support student learning; Numbers 6 and 7 represent how the students use the technology tool; Numbers 10, 11, 12, 13, 24, 27, 29, and 42 with question marks "?" are Yes/No choices. Numbers 30 – 41 are Teacher Self-Efficacy questions. Numbers 43 to 52 are the 10 content areas in mathematics.

[1Q5 Highest level of education they have completed
2Q8 What class they teach
3Q13_2 Desktop Computers for support
4Q13_3 Laptops for support
5Q13_4 Tablets for support
6Q14_1 Students watching videos on YouTube and/or other streaming apps
7Q14_4 Students listening to music
8Q15 How often students use tech in a day
9Q16 How often students use tech in a week
10Q17_1 Digital assessment technologies used?
11Q18_1 Tech help students learn a concept faster?
12Q19_1 Tech will help students think and learn more deeply?

13Q21_1 Should students use more/less tech in class?

14Q23_2 Teacher-directed small group instruction

15Q23_4 Individual (independent) instruction

16Q23_5 Computer or tech-based instruction

17Q24_1 Teacher-directed whole class active learning

18Q24_2 Teacher-directed small group active learning

19Q24_3 Student-directed small group active learning

20Q24_4 Individual (independent) active learning

21Q24_5 Computer or tech-based active learning

22Q25 Where students use computers

23Q26 Student/Computer ratio in the classroom

24Q28 Students allowed to take tablets home?

25Q30 Internet use for teacher planning and preparation

26Q31 How well teachers feel prepared to use computers and internet

27Q32 Does school require tech training?

28Q33 Number of hours of professional development in computer use

29Q35 Do you have tech support person?

30Q36 How much you can do to control disruptive behavior in the classroom

31Q37 How much you can do to motivate students who show low interest in school work

32Q38 How much you can do to get students to believe they can do well in school work

33Q39 How much you can do to help your students value learning

34Q40 To what extent you can craft good questions for your students

35Q41 How much you can do to get children to follow classroom rules

36Q42 How much you can do to calm a student who is disruptive or noisy

37Q43 How well you can establish a classroom management system with each group of students

38Q44 How much you can use a variety of assessment strategies

39Q45 To what extent you can provide an alternative explanation or example when students are confused

40Q46 How much you can assist families in helping their children do well in school

41Q47 How well you can implement alternative strategies in your classroom

42Q48 During the COVID-19 pandemic, did you transition to online teaching?

43Q51_1 Number Properties and Operations

44Q51_2 Measurement

45Q51_3 Geometry

46Q51_4 Data Analysis

47Q51_5 Algebra

48Q51_6 Data Analysis, Statistics and Probability

49Q51_7 Algebra and Functions

50Q51_8 Operations and Algebraic Thinking

51Q51_9 Operations with Numbers

52Q51_10 Foundations of Counting]

Below are the predictive results from pre-service teachers on the effect of COVID on Mathematics. Due to the large data, I will ignore those features with zero statistical significance and present only those with negative and positive significances.

Lack of Engagement

Accuracy: 1.0

Confusion matrix: [[8 0]
[0 16]]

The sum of correct classifications is 24; sum of misclassifications is 0. Total = 24.

The coefficients include:

[[0.3712773	0.	0.	0.	0.	0.
0.	-0.08057194	-0.61858332	-1.69847035	2.04597754	0.
0.	0.07384066	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.

0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.45413448
0.	0.	0.07838919	0.]]		

Table 20: Pre-service Post COVID Lack of Engagement

Negative Significance	Positive Significance
• How often students use tech in a day (-0.08) • How often students use tech in a week (-0.61) • Digital assessment technologies used? (-1.69)	• Highest level of education they have completed (0.37) • Teacher-directed small group instruction (0.07) • **Tech help students learn a concept faster? (2.04)** • Data Analysis, Statistics and Probability (0.45) • Operations with Numbers (0.07)

A high coefficient of 2.04 with "Tech help students learn a concept faster?" coded as 0 for "No" and 1 for "Yes" could imply that in scenarios where teachers believe strongly in technology's ability to speed up learning, or where technology is indeed effective in this regard, there may be an unintended increase in student disengagement. This could be due to various reasons, such as over-reliance on technology, reduced teacher-student interaction, or a mismatch between technology use and student learning styles.

Lack of Attendance

Accuracy: 0.95

Confusion matrix: [[19 1]
[0 4]]

The sum of correct classifications is 23; sum of misclassifications is 1. Total = 24.

The coefficients include:

[[0.65247451	0.09993236	0.	0.49466601	0.	0.

0.	0.	0.	0.	0.	0.
-0.36670049	0.	-0.80389589	0.	0.	0.
0.	0.	0.	0.	0.	0.08020186
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	-0.816501	0.	0.	0.	0.
0.	0.	0.	0.	1.50061336	0.
0.78517889	0.	0	0.]]		

Table 21: Pre-service Post COVID Lack of Engagement

Negative Significance	Positive Significance
• Should students use more/less tech in class? (-0.36) • Individual (independent) instruction (-0.80) • How much you can use a variety of assessment strategies (-0.81)	• Highest level of education they have completed (0.65) • What class they teach (0.09) • Laptops for support (0.49) • Students allowed to take tablets home? (0.08) • **Algebra (1.50)** • **Algebra and Functions (0.78)**

This shows that higher educational qualifications of pre-service teachers might correlate with higher student absenteeism. The specific class taught by pre-service teachers has a slight correlation with the lack of attendance. However, “Algebra”, “Algebra and Functions” suggests that these math content areas are associated with a notable increase in student absenteeism.

Lack of Motivation

Accuracy: 0.92

Confusion matrix: [[13 1]
[1 9]]

The sum of correct classifications is 22; sum of misclassifications is 2. Total = 24.

The coefficients include:

[[0	0.	0.	0.	0.	0.
1.0417591	0.	0.	-0.62168658	0.	0.67185012

0.	0.24830166	0.	0.	0.	0.
0.	0.	0.	0.	-0.47035852	0.
0.22942399	0.	0.	0.	0.1672191	0.
0.	0.	0.	0.	0.	0.
0.	0	0.	0.	-0.39337293	1.16806825
0.	0.	0.	0.23848671	0.	0.
0.	0.	-0.19331005	0.]]		

Table 22: Pre-service Post COVID Lack of Motivation

Negative Significance	Positive Significance
• Digital assessment technologies used? (-0.62) • Student/Computer ratio in the classroom (-0.47) • How well you can implement alternative strategies in your classroom? (-0.39) • Operations with Numbers (-0.19)	• Students listening to music (1.04) • Tech will help students think and learn more deeply? (0.67) • Teacher-directed small group instruction (0.24) • Internet use for teacher planning and preparation (0.22) • Do you have tech support person? (0.16) • **During the COVID-19 pandemic, did you transition to online teaching? (1.16)** • Data Analysis (0.23)

This could be interpreted as stating that those pre-service teachers that transitioned to online teaching taught students that were experiencing lack of motivation.

Supporting different levels of students in the same course

Accuracy: 1.0

Confusion matrix: [[6 0]
[0 18]]

The sum of correct classifications is 24; sum of misclassifications is 0. Total = 24.

The coefficients include:

[[0.19560951	-0.26047774	0.	0.	0.	0.
0.	0.	0.7193219	0.	0.	-0.28175497
0.	0.	0.	-1.30761989	0.	0.
0.	0.	0.	0.	-0.18038002	0.

0.23377841	0.	0.	0.	0.	0.
0.	-0.05020535	-0.45447334	0.39853446	0.	0.
0.	0	-0.65328389	0.	0.95145952	0.
0.	0.	0.	0.	0.	0.
0.	0.	-0.03879394	-0.09055501]]		

Table 23: Pre-service Post COVID Supporting different levels of students in the same course

Negative Significance	Positive Significance
• What class they teach (-0.26) • Tech will help students think and learn more deeply? (-0.28) • Computer or tech-based instruction (-1.30) • Student/Computer ratio in the classroom (-0.18) • Internet use for teacher planning and preparation (0.23) • How much you can do to get students to believe they can do well in school work (-0.05) • How much you can do to help your students value learning (-0.45) • To what extent you can provide an alternative explanation or example when students are confused (-0.65) • Operations with Numbers (-0.03) • Foundations of Counting (-0.09)	• Highest level of education they have completed (0.19) • How often students use tech in a week (0.71) • To what extent you can craft good questions for your students (0.39) • **How well you can implement alternative strategies in your classroom? (0.95)**

The large value of 0.95 shows that there's a strong correlation between alternative strategies and supporting different levels of students. It means that if teachers are good at using different ways to teach, it's very important for helping students who are at different learning stages. Teachers who can change and adjust how they teach are better at meeting the varied needs of their students, and this is even more important after the COVID-19 pandemic.

Lack of Discipline

Accuracy: 0.96

Confusion matrix: [[10 1]
[0 13]]

The sum of correct classifications is 23; sum of misclassifications is 1. Total = 24.

The coefficients include:

[[0.15203748	-0.02752686	0.	0.24611281	0.	0.
-0.05393239	0.	-0.21801673	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	-0.09938225	0.	0.20836962	0.
0.71292092	0.	0.	0.	-0.04713571	0.
0.	0.	-0.45447334	0.10415229	-0.94740775	0.
0.	1.02643534	0.	-0.62740968	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.1981967	0.]]		

Table 24: Pre-service Post COVID Lack of Discipline

Negative Significance	Positive Significance
• What class they teach (-0.02) • Students listening to music (-0.05) • How often students use tech in a week (-0.21) • Computer or tech-based active learning (-0.09) • Do you have tech support person? (-0.04) • How much you can do to help your students value learning (-0.45) • How much you can do to get children to follow classroom rules (-0.94) • How much you can assist families in helping their children do well in school (-0.62)	• Highest level of education they have completed (0.15) • Laptops for support (0.24) • Student/Computer ratio in the classroom (0.20) • Internet use for teacher planning and preparation (0.71) • To what extent you can craft good questions for your students (0.10) • **How much you can use a variety of assessment strategies (1.02)** • Operations with Numbers (0.19)

The highest coefficient of 1.02 suggests a very strong positive relationship. This implies that flexibility in the use of various assessment strategies can help detect students' lack of discipline and therefore, disciplinary action can therefore be taken to correct them.

Lack of Parental Support

Accuracy: 0.88

Confusion matrix: [[12 1]
[2 9]]

The sum of correct classifications is 21; sum of misclassifications is 3. Total = 24.

The coefficients include:

[[0.	0.	0.	0.	0.	0.
0.	0.	0.63165094	0.	0.32409711	0.
0.25123073	0.	0.	0.	0.	0.
0.	0.	0.13274931	0.02551982	-0.42748609	0.
0.18345683	0.05465012	0.	0.	0.	0.
0.	-0.63367921	0.	0.	-0.12019932	0.42378356
0.	0.	0.	-0.30004484	0.	0.
0.	0.	0.	0.	1.02153878	0.
0.	0.	0.127656683	0.]]		

Table 25: Pre-service Post COVID Lack of Parental Support

Negative Significance	Positive Significance
• Student/Computer ratio in the classroom(-0.42) • How much you can do to get students to believe they can do well in school work (-0.63) • How much you can do to get children to follow classroom rules (-0.12) • How much you can assist families in helping their children do well in school (-0.30)	• How often students use tech in a week (0.63) • Tech help students learn a concept faster? (0.32) • Should students use more/less tech in class? (0.25) • Computer or tech-based active learning (0.13) • Where students use computers (0.02) • Internet use for teacher planning and preparation (0.18) • How well teachers feel prepared to use computers and internet (0.05) • How much you can do to calm a student who is disruptive or noisy (0.42) • **Algebra (1.02)** • Operations with Numbers (0.12)

These findings suggest that various aspects of technology use in education, certain teaching methods and the focus on Algebra content are correlated with differing degrees of lack of parental support.

These correlations might indicate that increased technology use and certain educational content areas are perceived by parents as less effective or less supportive for their children, leading to a decrease in their support.

4.5 Descriptive Analysis of the Effect of COVID

The pre-service teachers responded that 12 (50%) of them transitioned to online teaching during the pandemic while 12 (50%) did not transition. One of the responses reads "I was not teaching during COVID". Their responses on the challenges they are currently facing in the classroom with regards to teaching their students show that "Supporting different levels of students in the same course" and "Lack of engagement" were at the top of the list.

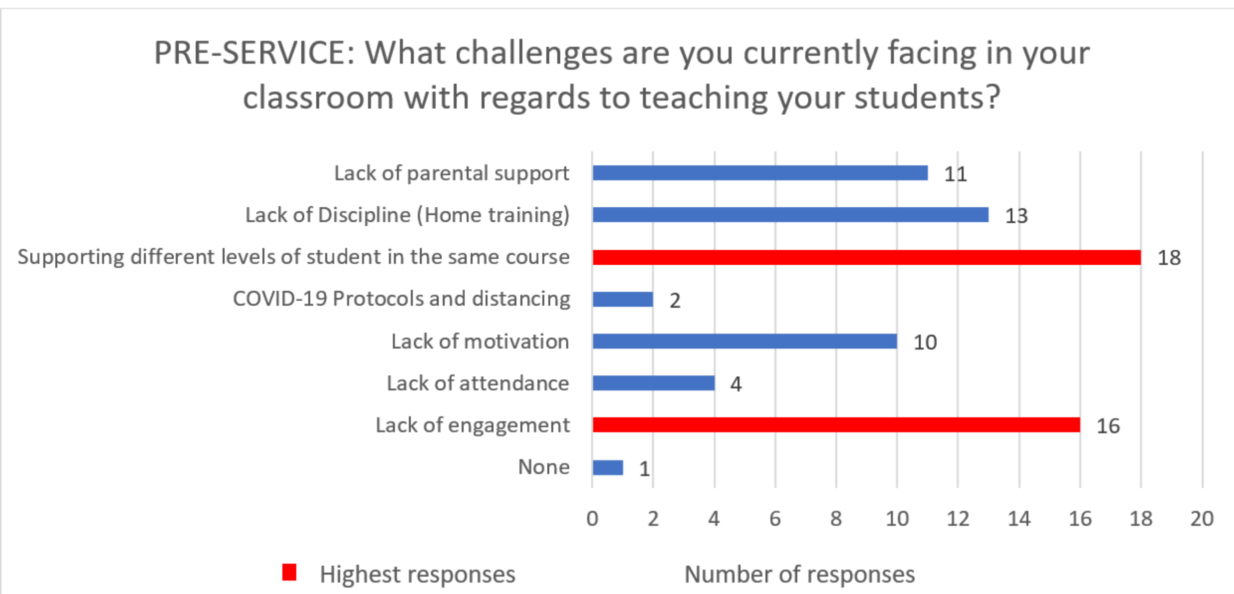


Figure 10: Challenges pre-service teachers currently face in the classroom.

Also, results from these teachers show that they feel students need reinforcement in mathematics content areas such as: a) Operations and Algebraic Thinking (OAT); b) Algebra. From the ALCoSM, students that learn OAT are grades K – 5 then they transition to Algebra for grades 6 – 12. Could it be that OAT which should have been completed at elementary school still has lapses which is why even at high school, students still have problems in Algebra? More research is needed to understand and confirm these results.

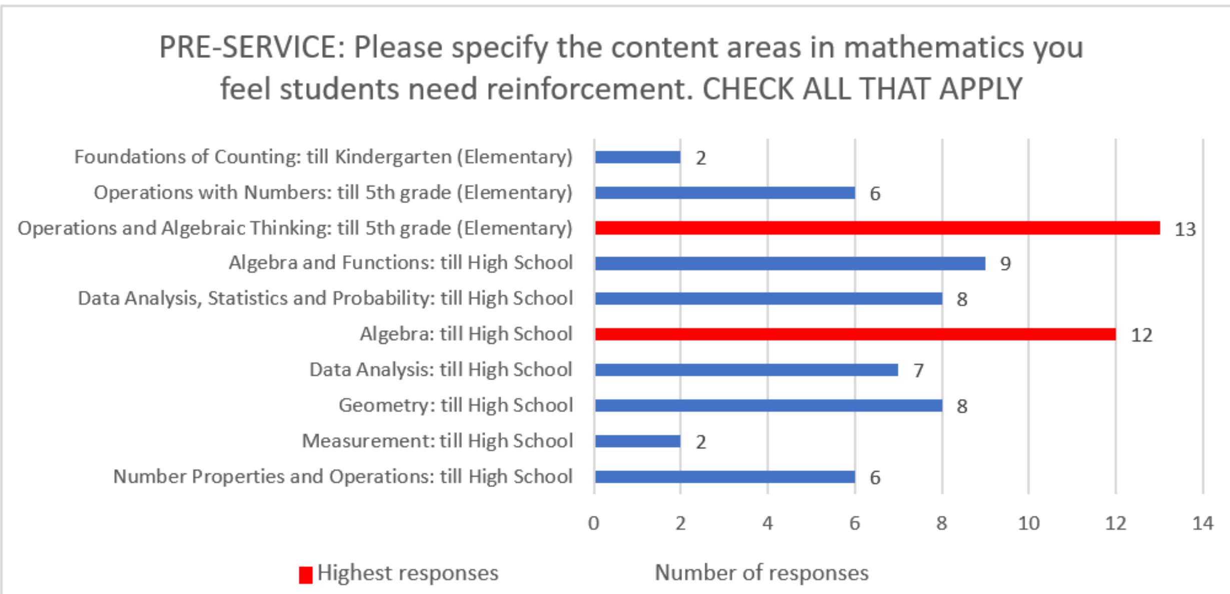


Figure 11: Content areas pre-service teachers think students need reinforcement

The in-service teachers gave an insight to challenges they faced with students during COVID. The greatest challenge was “Lack of attendance”. Others were “Lack of engagement”, “Lack of motivation”, and “Lack of discipline” which were all ties.

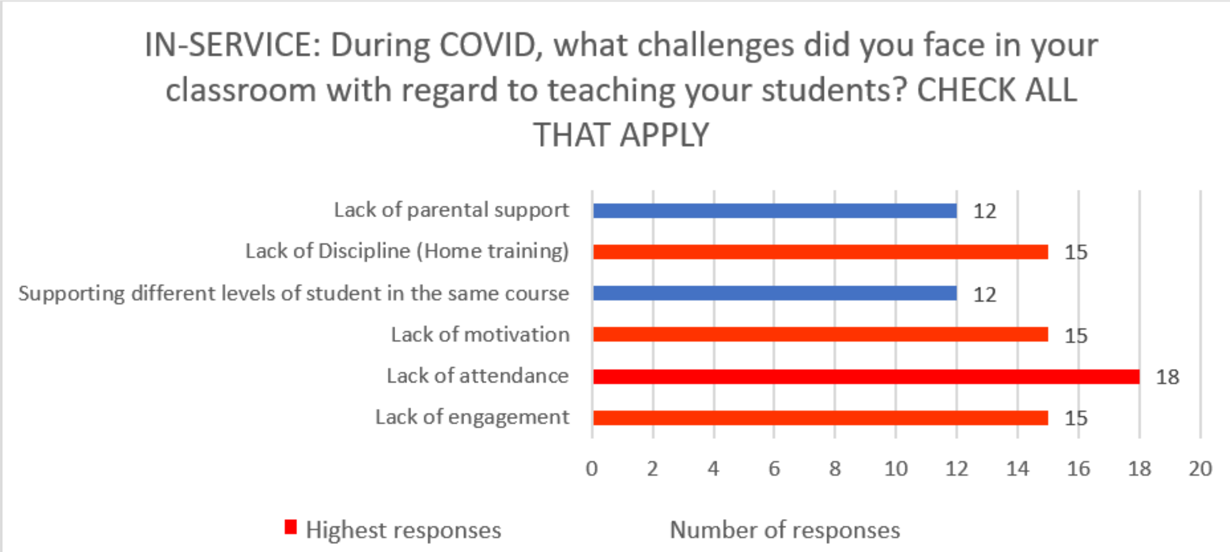


Figure 12: Challenges in-service teachers faced during COVID

Looking at the results from in-service teachers on the challenges they are currently facing (post-COVID), the highest problem is "Lack of motivation" with 18 hits. Others are "Lack of attendance" and Lack of discipline" which are ties with 15 hits.

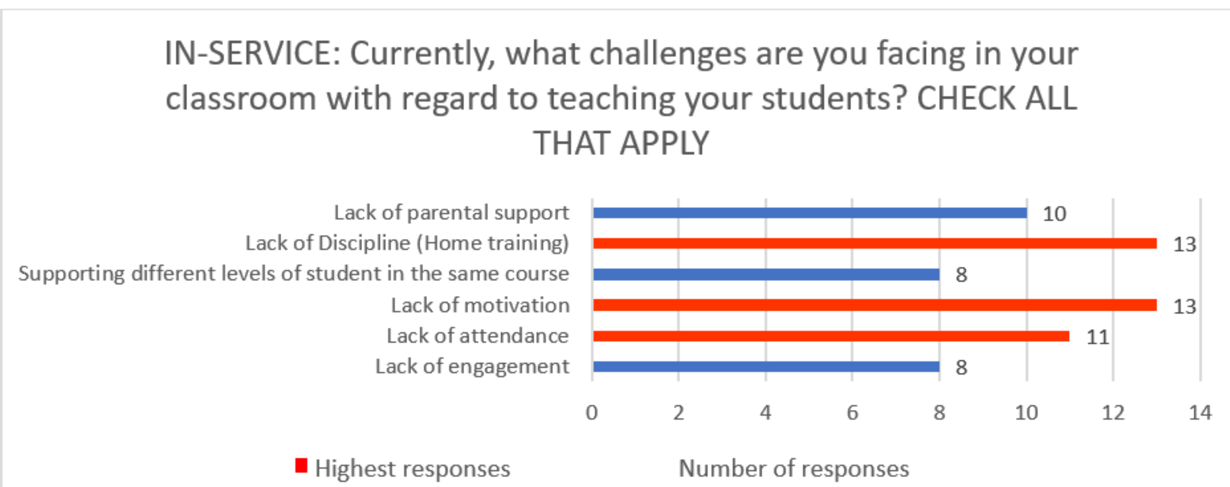


Figure 13: Challenges in-service teachers are currently facing in their classrooms

Results from in-service teachers on content areas of mathematics for reinforcement show that the highest is Algebra. Another is Number Properties and Operations. These two content areas are taught from K – 12th grades. On the other hand. Operations and Algebraic Thinking (OAT) is taught from K – 5th grade came third place. This is highlighted in yellow because OAT was the highest priority for reinforcement from the pre-service teachers results.

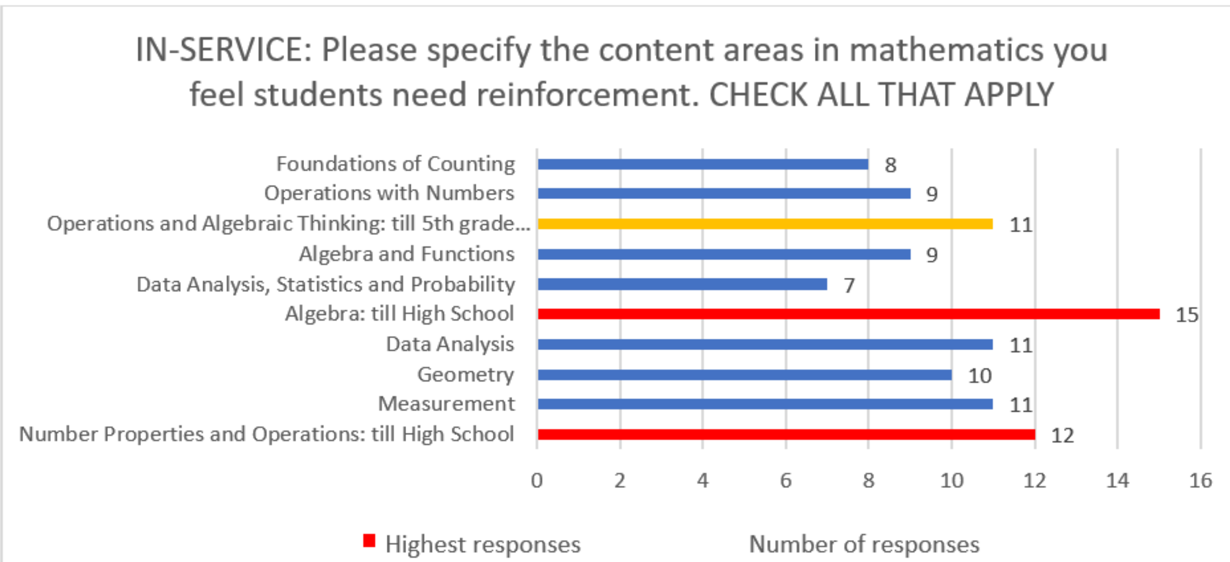


Figure 14: Content areas in-service teachers feel students need math reinforcement

4.6 Discussions and Conclusions

The regression model can be adopted, expanded and re-applied in all realms of teaching to better understand reasons behind challenges experienced by teaching in all levels of education (elementary, middle, high, college and graduate levels). A large coefficient means that the predictor has a strong impact on the response variable.

One of the response variables - Lack of attendance for in-service shows that male teachers are strongly associated with higher lack of attendance compared to female teachers. This is consistent during and post COVID. Teachers with long-track teaching and/or older teachers were somewhat persistent with the negative attributes of the students (lack of engagement, lack of attendance, etc.). Further research is needed to investigate all these correlations to better understand the underlying reasons and addressing them effectively. It is very important to note that these results are associative relationships and the real causes could be multifaceted and influenced by various external factors.

From the in-service and pre-service teachers' responses, the top three math content areas they feel students need reinforcement in decreasing order are: a) Algebra; b) Operations and Algebraic Thinking; c) Number Properties and Operations. The goal of this research is to conduct assessments to pinpoint those specific areas where students are struggling and therefore, provide an accelerated learning framework which will cater to individual student's strengths and weaknesses, leading to improved educational outcomes and enhanced learning experiences.

Chapter 5 System Design

5.1 User-Centered Design Approach

User-centered design (UCD) is a design philosophy and process that places the users and their needs at the forefront of product development. Implementing a UCD approach in creating a web-based accelerated learning framework for teaching mathematics in Alabama schools, especially focusing on "Algebra", "Operations and Algebraic Thinking", and "Number Properties and Operations" involves several key steps: a) Understanding the users by utilizing the survey results to understand the specific needs in mathematics education; b) Defining requirements by defining clear goals for the learning framework which includes catering to different learning styles and addressing the identified areas of struggle in mathematics; c) Design and Development of the application and incorporating interactive contents like videos; d) Testing and Feedback with pre-service teachers to ensure the platform is user-friendly, easy to use and provide overall satisfaction; e) Implementation and Evaluation.

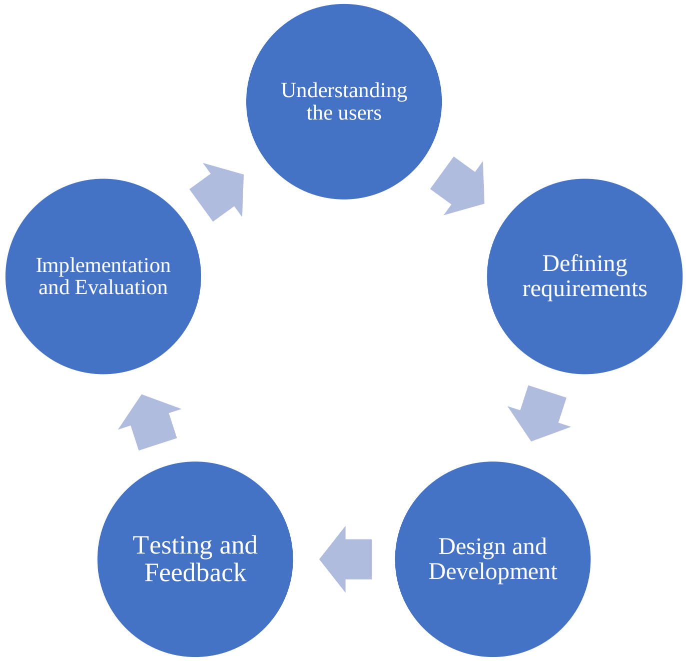


Figure 15: User-Centered Design Lifecycle

5.2 LEAP Design: Alignment with the *2019 Alabama Course of Study: Mathematics (ALCoSM)*

The LEAP application utilizes the ALCoSM framework. The visual representation of the 2019 Alabama Course of Study: Mathematics, known as the conceptual framework graphic, illustrates its purpose of ensuring that all students receive comprehensive mathematics education. This education aims to provide them with the necessary preparation to pursue further educational and professional opportunities, understand and critically analyze the world, and appreciate the joy, wonder, and beauty of mathematics (NCTM, 2018). The graphic depicts this purpose through a cyclical pattern formed by position statements, content, student mathematical practices, and mathematics teaching practices. At the center of the cycle is the representation of a mathematically-prepared graduate, symbolized by a diploma and mortarboard. The cycle has no specific starting or ending point, emphasizing that all its components must be continuously integrated into mathematics teaching and learning. The integration of these components is essential in developing an excellent mathematics education program for public schools in Alabama, as represented by the shaded map of the state in the background. The four critical components of this program are Student Mathematical Practices, Alabama Content Areas and 9-12 Essential Content, Mathematics Teaching Practices, and Position Statements.

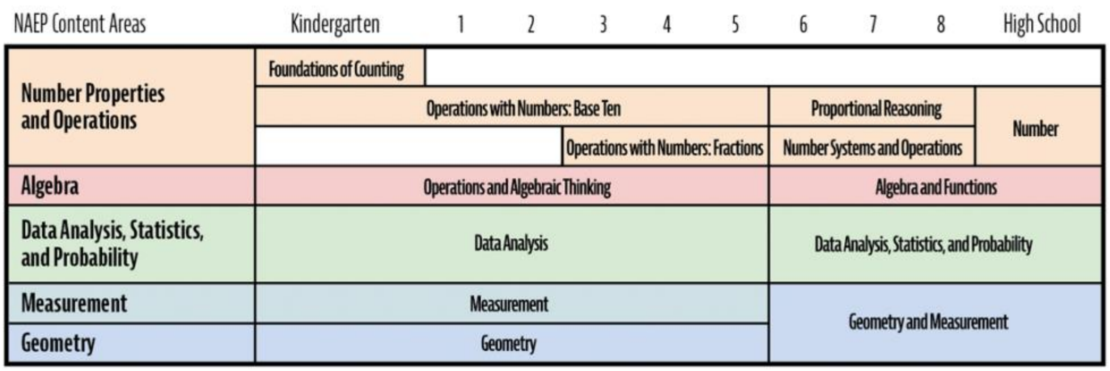


Figure 16: Overview of Alabama Content Areas

The Student Mathematical Practices, also known as the Standards for Mathematical Practice, embody the processes and proficiencies in which students should regularly engage while learning mathematics. These practices include problem-solving and perseverance, constructing arguments and critiquing reasoning, modeling, using appropriate tools, precision in mathematical communication, identifying and utilizing mathematical structures, and recognizing patterns and regularities. Proficiency in these practices is crucial for applying mathematics in both academic and real-life contexts. The Mathematical Practices are a key component of the National Assessment of Educational Progress (NAEP) framework and are incorporated as Alabama standards across all grades. Further details about these practices can be found on pages 11-14.

The content standards serve as the vehicle for developing the Student Mathematical Practices and specify the knowledge and skills students should acquire by the end of each grade or course. These standards are organized into Alabama Content Areas, which align with the content areas in the 2025 NAEP mathematics framework. The design of these standards ensures a coherent and effective progression of learning across grades, ensuring students are well-prepared for future success.

In Grades 9-12, the Alabama Content Standards are further organized into subgroups of essential concepts as described in the National Council of Teachers of Mathematics (NCTM) publication, Catalyzing Change in High School Mathematics: Initiating Critical Conversations (2018). These essential concepts are intended to be achieved by all students within the first three years of high school mathematics, laying the groundwork for additional coursework that aligns with their individual post-high school needs and interests.

The final component of the cycle consists of the eight Mathematics Teaching Practices (NCTM, 2014), which should be consistently incorporated into every mathematics lesson from kindergarten to grade 12. These practices provide guidance to educators on effective teaching strategies that promote student engagement, conceptual understanding, problem-solving abilities, and mathematical proficiency. These include:

1. Establishing clear learning goals in mathematics. Effective mathematics teaching involves setting specific goals for students' mathematical learning, placing these goals within a progression of learning, and using them to guide instructional decisions.
2. Promoting reasoning and problem-solving tasks. Effective mathematics teaching encourages students to engage in tasks that require mathematical reasoning and problem-

solving. These tasks should offer multiple entry points and allow for various solution strategies.

3. Connecting and utilizing mathematical representations. Effective mathematics teaching involves helping students make connections between different mathematical representations. This deepens their understanding of mathematical concepts and procedures and enables them to use representations as tools for problem-solving.

4. Facilitating meaningful mathematical discourse. Effective mathematics teaching fosters discourse among students, enabling them to develop a shared understanding of mathematical ideas. This includes analyzing and comparing student approaches and arguments.

5. Asking purposeful questions. Effective mathematics teaching utilizes purposeful questions to assess and enhance students' reasoning and understanding of important mathematical concepts and relationships.

6. Developing procedural fluency based on conceptual understanding. Effective mathematics teaching builds fluency in mathematical procedures upon a foundation of conceptual understanding. This approach enables students to skillfully apply procedures flexibly when solving both real-world and mathematical problems.

7. Supporting productive struggle in mathematical learning. Effective mathematics teaching consistently provides students with opportunities and support to engage in productive struggle as they wrestle with mathematical ideas and relationships, both individually and collaboratively.

8. Eliciting and utilizing evidence of student thinking. Effective mathematics teaching uses evidence of students' thinking to assess their progress in understanding mathematics. This ongoing assessment informs instructional adjustments that support and extend students' learning.

An excerpt from the ALCoSM states:

“The course of study does not dictate curriculum, teaching methods, or sequence. Each local education authority (LEA) should create its own curriculum and pacing guide based on the Course of Study. LEAs may add standards to meet local needs and incorporate local resources. Even though one topic may be listed before another, the first topic does not have to be taught before the second. A teacher may choose to teach the second topic before the first; to teach both at the same time to highlight connections; or to select a different topic that leads to students reaching the standards for both topics”.

In this research, we will incorporate other elements for robust teaching especially for under resourced schools that don’t have access to these provisions.

5.3 Interpreting the Content Standards

Alabama Content Areas are groups of related Content Standard (C1, C2, …, CN). In the example below, the first Alabama Content Area for 6th grade is “Number Properties”. Others include: "Algebra ", "Data Analysis, Statistics and Probability", "Measurement" and "Geometry". The content standard increments sequentially throughout the grade level while the sub-content standard increases within the content standard. Because mathematics is a connected subject, standards from different content areas may sometimes be closely related. Each Content Area may have several sub-content areas (1, 2, …, N) listed to the right containing the minimum required content and define what students should know and be able to do at the conclusion of a course or grade. Content standard increments sequentially throughout the grade level while the sub-content standard increases within the content standard. The groups between the grades are: K – 2, 3 – 5, 6 – 8, and 9 -12. This research will focus on grades 6 – 8 and the approach can be used to build the framework for other grade groups.

Table 26: Grade 6 Mathematics Overview

Number Properties		**Algebra**		**Data Analysis, Statistics and Probability**		**Measurement**		**Geometry**	
Content Standard (C1, C2, …, CN)	Sub-Content standard (1, 2, …, N)	Content Standard (C1, C2, …, CN)	Sub-Content standard (1, 2, …, N)	Content Standard (C1, C2, …, CN)	Sub-Content standard (1, 2, …, N)	Content Standard (C1, C2, …, CN)	Sub-Content standard (1, 2, …, N)	Content Standard (C1, C2, …, CN)	Sub-Content standard (1, 2, …, N)

Using the grade 6 overview example, C10 corresponds to Content standard 10 and is represented as 6.10. The sub-content standards for this grade is represented as 6.10.1, 6.10.2, …, 6.10.N. For Grades 6 – 8, there is an accelerated pathway for students that are highly motivated and learn at a faster rate. These consist of five courses: Grade 6, Grade 7, Grade 7 Accelerated, Grade 8, and Grade 8 Accelerated. If however, this pathway no longer suits the student, they can decide to exit and continue with the standard school pathway. Below are the 6 different pathways a student can implement from $\boldsymbol{Grade\ 6 \rightarrow Grade\ 7 \rightarrow Grade\ 8 \rightarrow Grade\ 9.}$

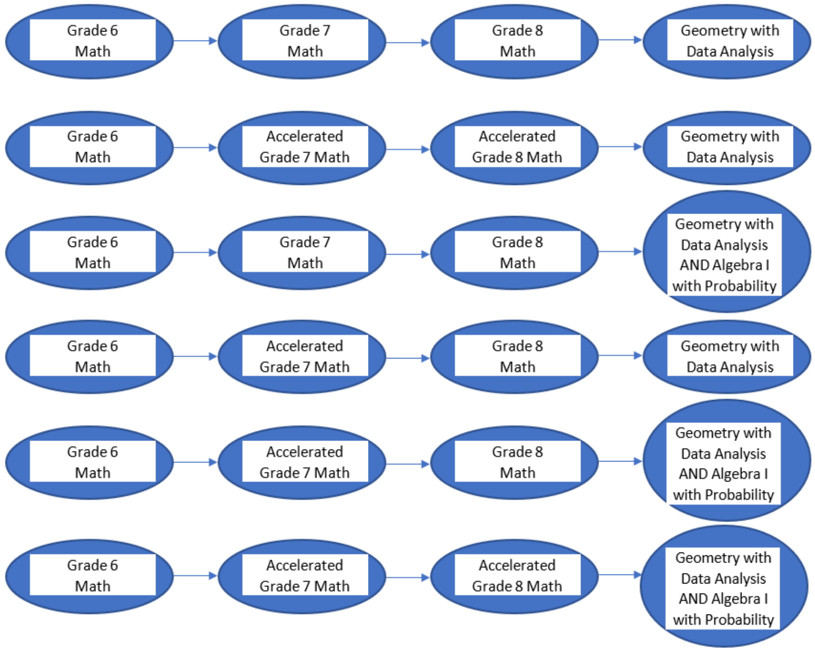


Figure 17: Accelerated pathways for Grades 6 - 8

5.4 Adaptability to the Common Core State Standards

5.4.1 Common Core Standards

Launched in 2010, the Common Core State Standards Initiative, often referred to as Common Core, sets forth a clear set of educational benchmarks for English language arts and mathematics. It outlines the specific knowledge and skills students in the United States should acquire by the end of each grade level, from kindergarten through the 12th grade. According to many individuals involved in the development of the Common Core, a significant flaw was identified: the standards were introduced without accompanying lesson plans, textbooks, and comprehensive teacher-training initiatives [After 10 years of Hopes and Setbacks, What happened to the Common Core? The New York Times. 2021]. This led to the adoption of respective state standards.

This following are from the Common Core State Standards: http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

Table 27: Common Core Standards for grades 6 - 8

C-Core Standards 6 Grade:	**C-Core Standards 7 Grade:**	**C-Core Standards 8 Grade:**
Ratios and Proportional Relationships 6.RP	Ratio and Proportional Relationships 7.RP	The Number System 8.NS
The Number System 6.NS	The Number System 7.NS	Expressions and Equations 8.EE
Expressions and Equations 6.EE	Expression and Equations 7.EE	Functions 8.F
Geometry 6.G	Geometry 7.G	Geometry 8.G
Statistics and Probability 6.SP	Statistics and Probability 7.SP	Statistics and Probability 8.SP

5.4.2 Mapping

The high-level mapping between grade levels is a standard pathway from one grade to another. If the path is from current grade to higher grade (e.g., from 6th to 7th), it is an *accelerated* pathway. If the reverse is the case, it is a *reinforcement* pathway.

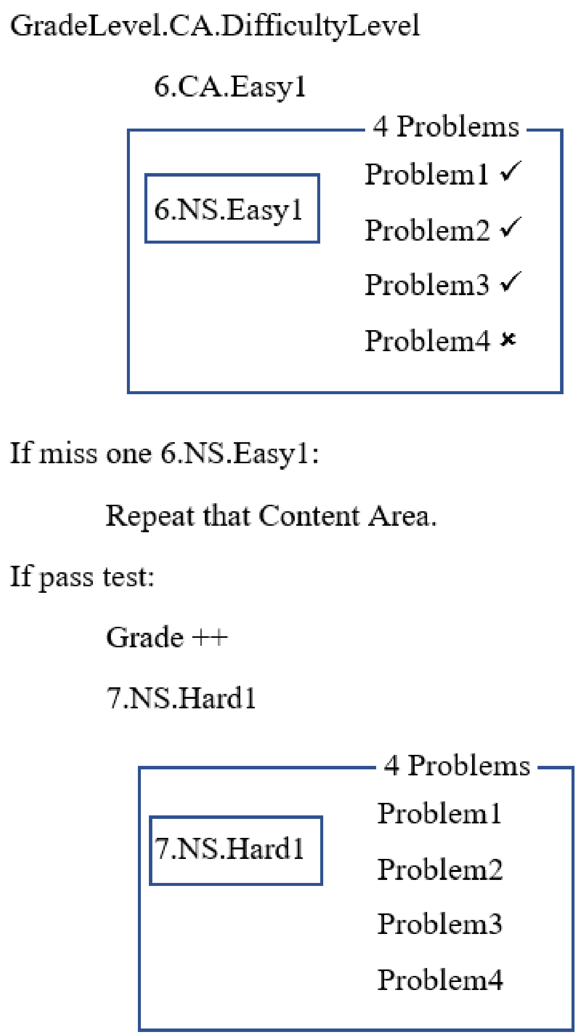
Table 28: High-level mapping for grades 6 - 8

Accelerated Pathway	Reinforcement Pathway
6.RP → 7.RP	7.RP → 6.RP
6.NS → 7.NS → 8.NS	8.NS → 7.NS → 6.NS
6.EE → 7.EE → 8.EE	8.EE → 7.EE → 6.EE
6.G → 7.G → 8.G	8.G → 7.G → 6.G
6.SP → 7.SP → 8.SP	8.SP → 7.SP → 6.SP

5.5 Components and Structure of the LEAP Framework

5.5.1 Advanced Personalized Learning

In this approach, a student's advancement is contingent upon their mastery of content at each level of difficulty. Students begin with an initial set of problems (e.g., four problems under 6.NS.Easy1) to assess their understanding in a specific content area (e.g., 6th grade Number Systems). If the student struggles with a particular problem (as indicated by the asterisk in Problem4), the system recognizes this and triggers a repetition of content focused on that area to reinforce understanding. The student continues to work on that content area until they achieve mastery. Mastery is demonstrated by correctly solving all the problems in the set without errors. Upon successful completion of the initial problem set, the student is advanced to a higher grade level with more challenging content (e.g., from 6.CA.Easy1 to 7.NS.Hard1), ensuring that the learning experience remains appropriately challenging. The system provides immediate feedback on each problem, allowing the student to understand their mistakes and learn from them in real-time. If a student demonstrates mastery, they progress to the next level. If not, they repeat the content area, possibly with new problems or additional support, until they can demonstrate understanding. The system collects data on student performance, which can be used to further personalize the learning experience, such as offering targeted exercises, modifying the pace of learning, or providing tailored instructional materials.



Below is the high-level flow model between different grade levels.

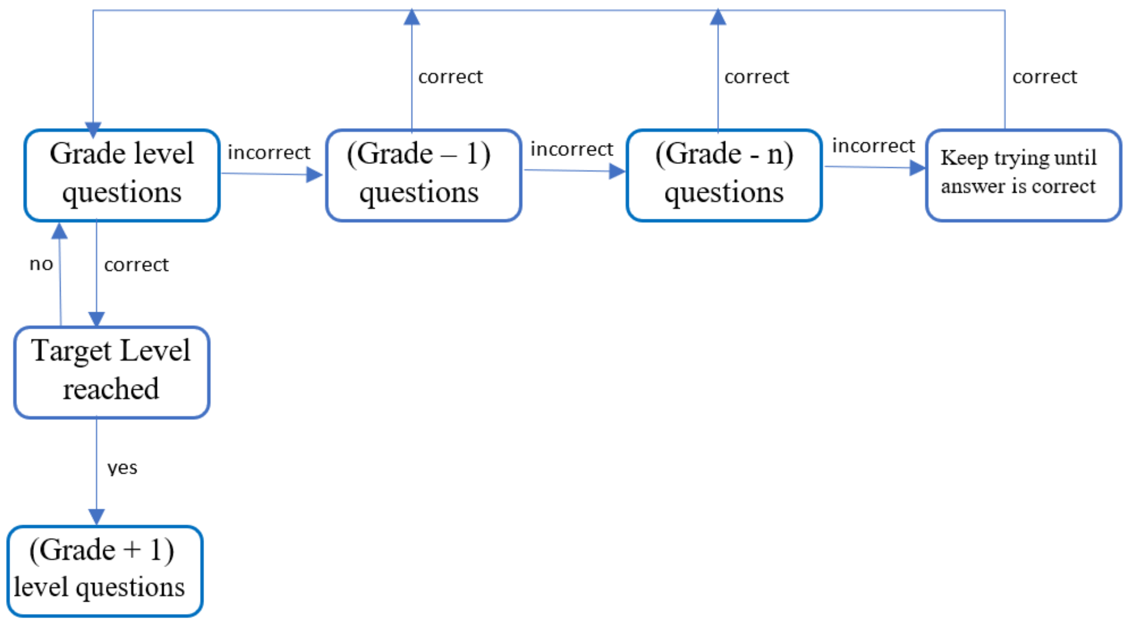


Figure 18: LEAP High level flow diagram between grade levels

In a situation the learner doesn't get the correct answer on the grade level content after some trials, the system will move 1 step backward to the immediate grade (Grade – 1) and even further (Grade – n). For this example, the learner can be taken from "grade 3" down to "grade 2" down to "grade 1" until there is a certainty, they have understood the foundational concepts. The learner will return to the grade level questions after succeeding to answer the question and will continue with grade level content questions. When the target level is reached for that grade, the learner can attempt questions from the next grade. A student in a grade level will take a proficiency test covering all 5 strands/content areas in the AL state standards – Number and Operations (N), Algebra (A), Geometry (G), Measurement (M) and Data Analysis and Probability (D). There are 10 questions from the different areas of that content area for a total of 100 points. Benchmark score for each grade level is 80%. If a student scores:

- 80% or higher, they accelerate to the next level which can be within the current grade level or higher grade in the mapping scheme.
- 79% – 50%, they are given extra lessons to remediate on the topics of interest and given the proficiency test again. This rule is repeated if necessary.
- 49% and lower, the system will use the pre-set PreK-12 mapping scheme and navigate to lower grade(s) of that sub-content area to ensure that they have the prerequisite knowledge, take quizzes for that grade and pass, before they return to their current grade-level. Once complete, the proficiency test is administered again. This rule is repeated if necessary.

5.5.2 Lookup Tables for CC vs ALCoSM

The Lookup table enables users to easily transition between common core (CC) and AL Course of Study: Math (ALCoSM).

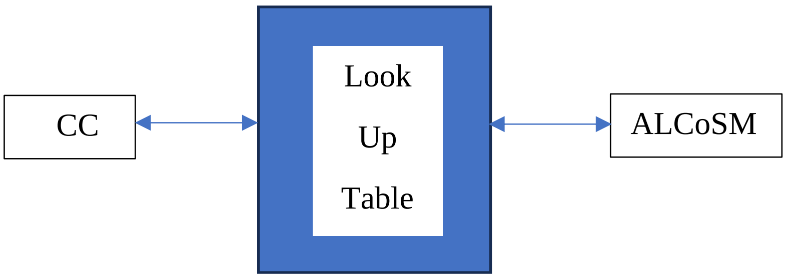


Figure 19: Lookup Table for CC and ALCoSM

Here is 6th grade course content for Number Systems CC and ALCoSM:

Common Core

6.NS.1 – Interpret and compute quotients of fractions.

6.NS.2 – Fluently divide whole numbers using the standard algorithm.

6.NS.3 – Fluently add, subtract, multiply, and divide decimals.

6.NS.4 – Find the GCF of 2 whole numbers =< 100 and LCF =< 12.

ALCoSM

6.4 - Interpret and compute quotients of fractions.

6.5 - Fluently divide multi-digit whole numbers using a standard algorithm.

6.6 - Add, subtract, multiply, and divide decimals.

6.8 - Find the GCF and LCM of two or more whole numbers.

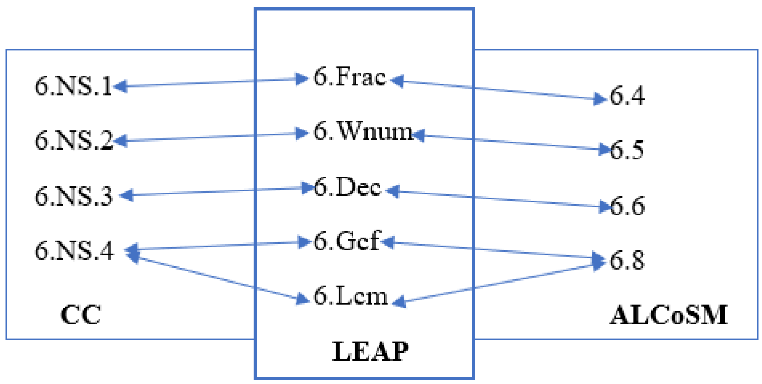


Figure 20: Lookup Table for 6th grade Numbers CC and ALCoSM

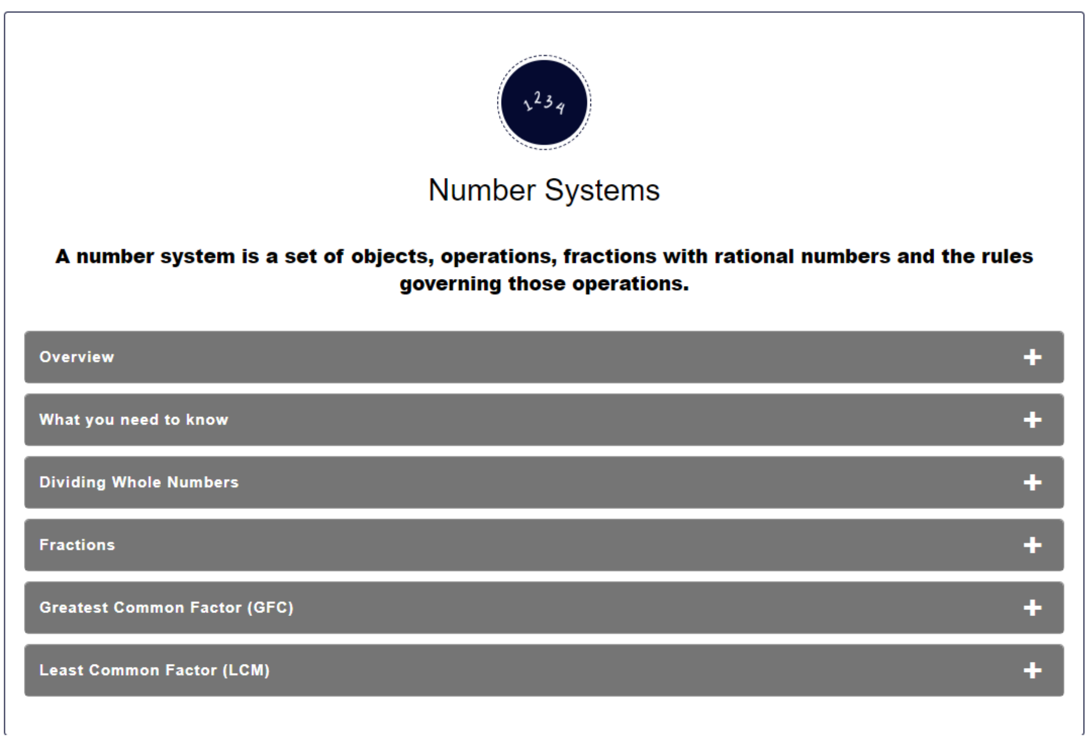


Figure 21: 6th grade Number Systems on LEAP framework

ALCoSM (Alabama Course of Study: Mathematics) content standards are numbered chronologically from 1, 2, 3, …, N.

6^{th} grade Number System level 1 is:

Common Core: 6.NS.1

AL standard: 6.4

Also, the first math areas for 6^{th} grade mathematics starts with Ratios and Proportional Relationships (RP), Number Systems (NS) and they include:

Common Core: 6.RP.1, 6.RP.2, 6.RP.3, 6.NS.1, 6.NS.2, 6.NS.3

AL Standard: 6.1, 6.2, 6.3, 6.4, 6.5, 6.6

Table 29: Showing comparison of representation of first 4 areas in 6th grade math in CC and ALCoSM

Common Core	6.RP.1	6.RP.2	6.RP.3	6.NS.1	6.NS.2	6.NS.3
ALCoSM	6.1	6.2	6.3	6.4	6.5	6.6

The complete math contents for 6th grade math is shown in the table below. Each Content Area has been color coded simultaneously for the different frameworks:

Table 30: Showing complete math contents for 6th grade ALCoSM and CC

ALCoSM for 6^{th} grade	CC for 6^{th} grade
6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10, 6.11, 6.12, 6.13, 6.14, 6.15, 6.16, 6.17, 6.18, 6.19, 6.20, 6.21, 6.22, 6.23, 6.24, 6.25, 6.26, 6.27, 6.28	6.**RP**.1, 6.RP.2, 6.RP.3, 6.**NS**.1, 6.NS.2, 6.NS.3, 6.NS.4, 6.NS.5, 6.NS.6, 6.NS.7, 6.NS.8, 6.**EE**.1, 6.EE.2, 6.EE.3, 6.EE.4, 6.EE.5, 6.EE.6, 6.EE.7, 6.EE.8, 6.EE.9, 6.**G**.1, 6.G.2, 6.G.3, 6.G.4, 6.**SP**.1, 6.SP.2, 6.SP.3, 6.SP.4, 6.SP.5

Findings:

1. ALCoSM will do the equivalent of 6.NS.8 (6.13) before 6.NS.7 (6.12).
2. ALCoSM swaps order for equivalence of 6.EE. Here is the adopted order equivalence:

6.EE.1, 6.EE.2, *6.EE.6*, *6.EE.3*, *6.EE.4*, *6.EE.5*, 6.EE.7, E.EE.8, 6.EE.9

3. ALCoSM covers Statistics (purple) before Geometry (orange) while CC covers Geometry before Statistics.
4. ALCoSM will do the equivalent of 6.SP.3 before 6.SP.2
5. ALCoSM swaps order for equivalence of 6.G. Here is the adopted order equivalence:

6.G.3, 6.G.1, 6.G.4, 6.G.2

Table 31: Showing complete math contents for 7th grade ALCoSM and CC

ALCoSM for 7th grade	CC for 7th grade
7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 7.10, 7.11, 7.12, 7.13, 7.14, 7.15, 7.16, 7.17, 7.18, 7.19, 7.20, 7.21, 7.22	7.**RP**.1, 7.RP.2, 7.RP.3, 7.**NS**.1, 7.NS.2, 7.NS.3, 7.**EE**.1, 7.EE.2, 7.EE.3, 7.EE.4, 7.**G**.1, 7.G.2, 7.G.3, 7.G.4, 7.G.5, 7.G.6, 7.**SP**.1, 7.SP.2, 7.SP.3, 7.SP.4, 7.SP.5, 7.SP.5, 7.SP.5, 7.SP.5

5.5.3 Guidebook

The LEAP framework and results gotten from this research can be used as a guide for future work.

5.6 User Experience Ethics Approval

The Auburn University Institutional Review Board approved this research to be conducted with PreK – 12th grade teachers. Protocol number is 22-106 EX 2209.

5.7 Design Implementation

The software development process that was used is Scrum – divided into multiple sprints. It is adaptable, flexible, and provides teams with a structured approach for incremental work delivery. Notably, scrum encourages regular collaboration among team members, fostering the development of interpersonal relationships and trust. It proves highly advantageous in scenarios like new software product development, especially when dealing with unclear or evolving requirements. The Scrum process enables developers to swiftly adjust to changing requirements and expedite the creation of a functional prototype, allowing customers to provide their input and guidance, which is pivotal in new software product development.

5.7.1 Sprint 1 – Wireframe

During the first sprint planning meeting, hand-drawn sketches were made. Thereafter, came the wireframes. These are visual representations of a system's layout, occasionally likened to a blueprint or skeletal structure. They serve the purpose of illustrating design concepts to clients, facilitating the establishment of mutual agreement on the proposed ideas. The picture below is the wireframe for the home page.

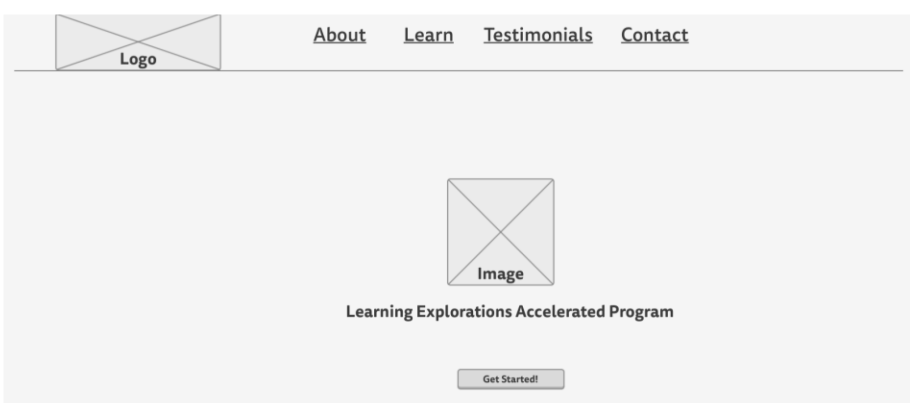


Figure 22: Wireframe for home page

The home page has standard elements like logo, headers and body content. In the figure above, there will be a central image located within the body. Next, is the wireframe for the "About" page.

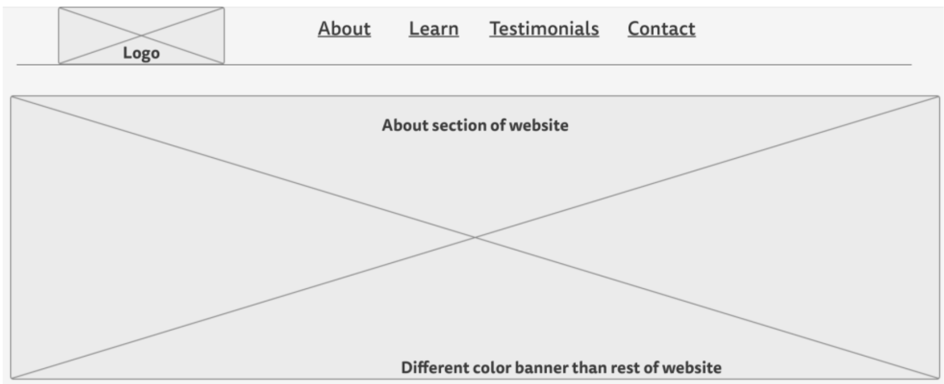


Figure 23: Wireframe for "About" page

The "About" page gives information about the LEAP website which will contain text and pictorial representations where necessary. Next, is the "Learn" page.

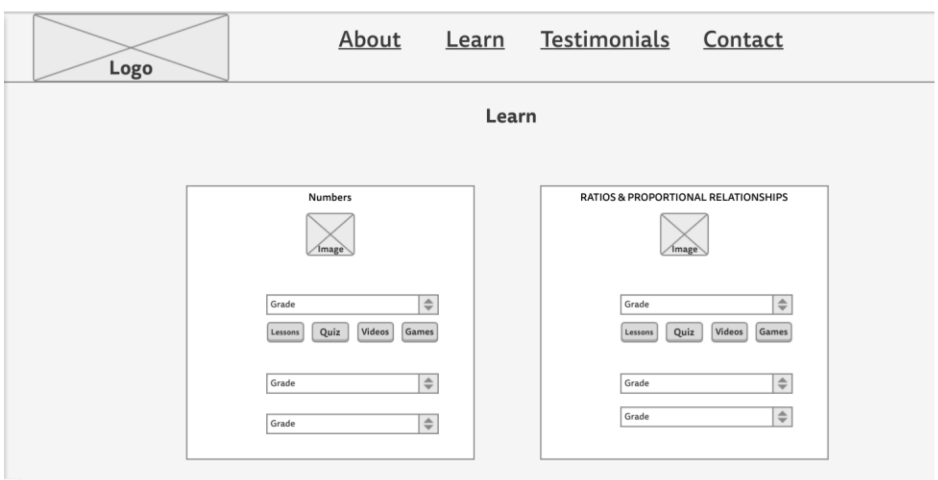


Figure 24: Wireframe for "Learn" page

From the “Learn” page, the user can choose a desired mathematics content area to assimilate. From the figure above, there are two options: “Numbers” and “Ratios & Proportional Relationships”. The student selects their grade level and begins the lesson.

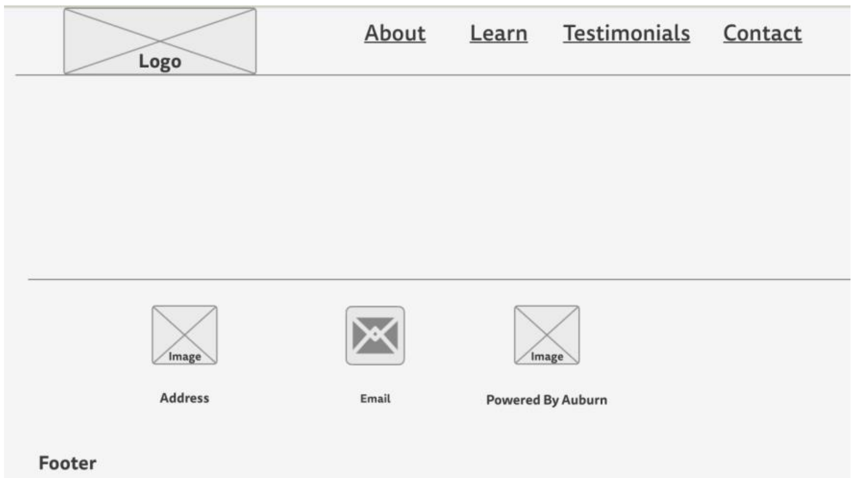


Figure 25: Wireframe for footer page

Finally, is the footer page which shows addresses affiliated with the software.

5.7.2 Sprint 2 – Prototype 1

After the wireframes were approved, the first mockups were created. The intention is to make them look closer to the final design. The figure below is the registration page.

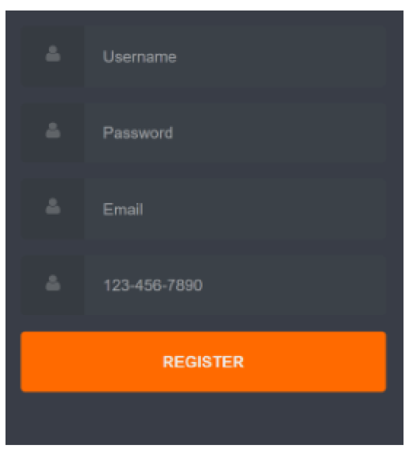


Figure 26: LEAP registration

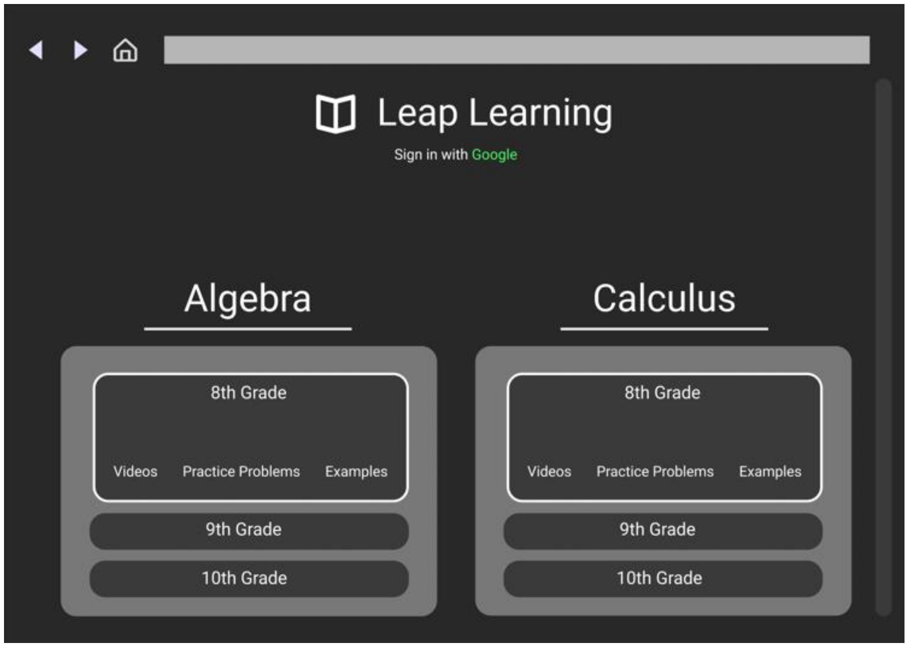


Figure 27: Prototype 1

Login authentication is being set up. After the student signs in and selects their grade, they can watch videos, practice problems or take the quiz. The videos are to elaborate more on the topic and for edutainment.

5.7.3 Sprint 3 – Prototype2

The dark interface was change to a bright one and a LEAP logo was created showing 3 students “leaping for joy”. The figure below shows the home page, “About” and “Learn” pages. The user selects their grade to start the lesson. At each level, there is a lesson, quiz, video and game.

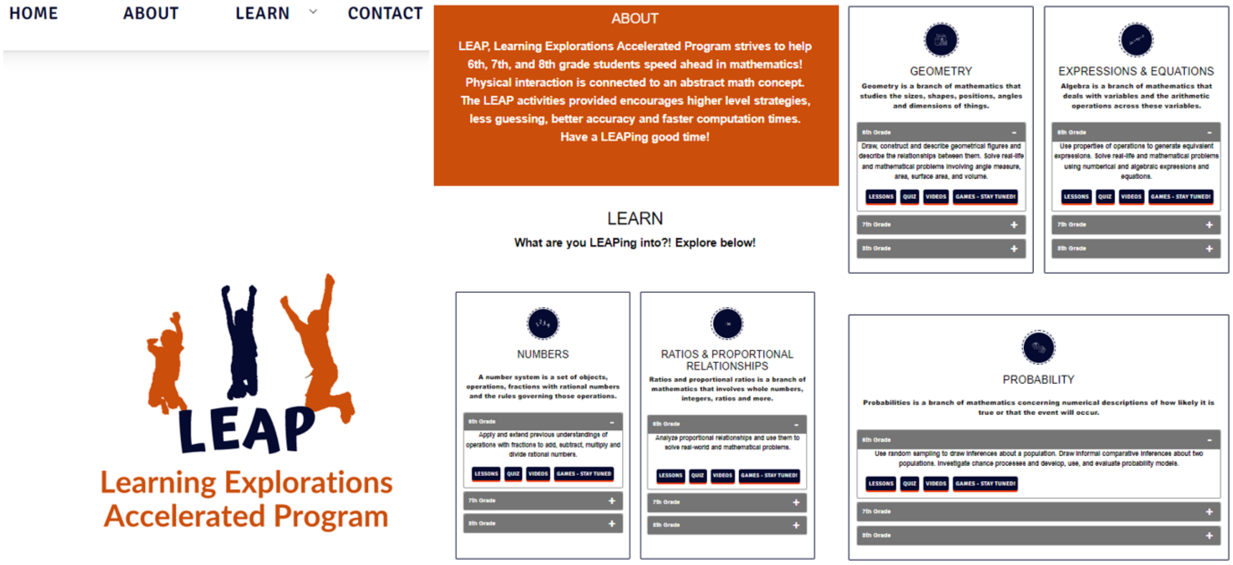


Figure 28: Prototype 2

5.7.4 Sprint 4 – Lesson Plan

The ALCoSM gives a framework for the content areas to teach at each grade level. For the sequence between grades levels, acceleration and reinforcement pathway, the coherence map was used. Here are some hand sketches for 6 – 8th grades covering all 5 content areas:

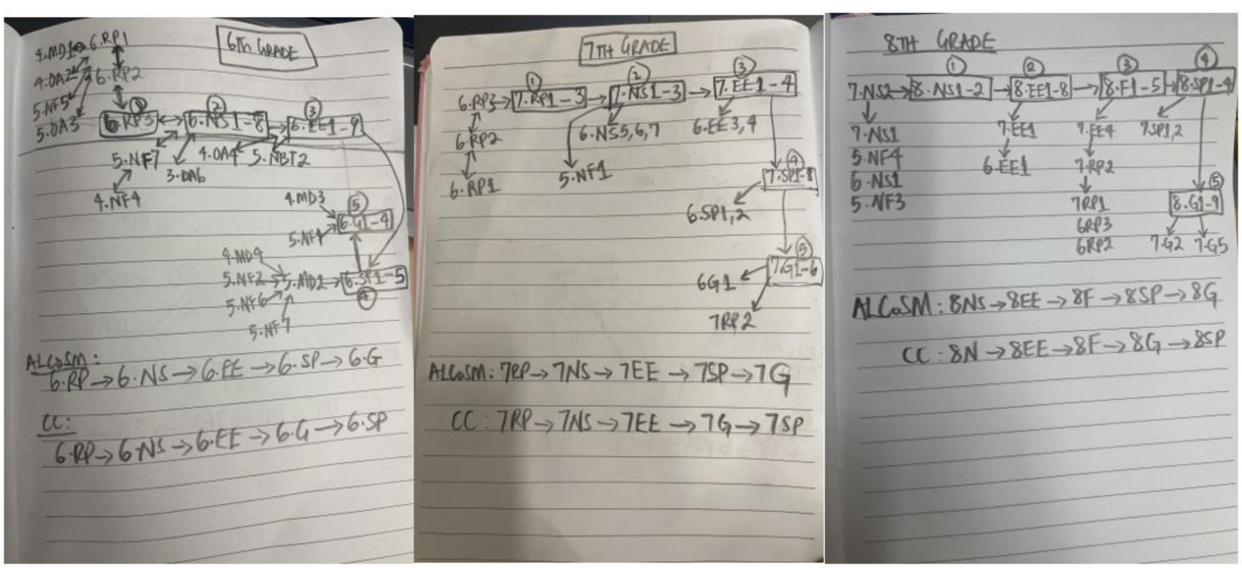


Figure 29: Lesson progression for 6-8th grades

5.7.5 Sprint 5 – High-Level Design

At each grade level, there are 5 main content areas. When a student clicks to begin a lesson, a brief summary of that content area is given. The lesson is grouped into sections to make the site coincise and less boring to the student. On the very top is the “Overview” which contains a 2 – minute video about what the lesson is all about. On clicking each section, it expands to teach that topic. The student progresses until they have covered the entire lesson. At the bottom, there is “Test Your Knowledge” which is a way to capture the attention and engagement of the users for self-assessment. There are maximum of 4 questions and the acceptable responses can be the letter answers “a”, “b”, “c”, “d”, or typing the exact answer. The student can decide to answer some or all of the questions and can revisit the corresponding lesson to help with answering the questions. When the “Submit” button is clicked, they are told if the answer is correct or wrong. The student can try the questions multiple times. The next step is to attempt the post quiz which contains 10 questions from the lesson and the results are saved in the database for each student. There is also a button to return to the home page. Below is the screenshot for 6^{th} grade Number Systems Lesson.

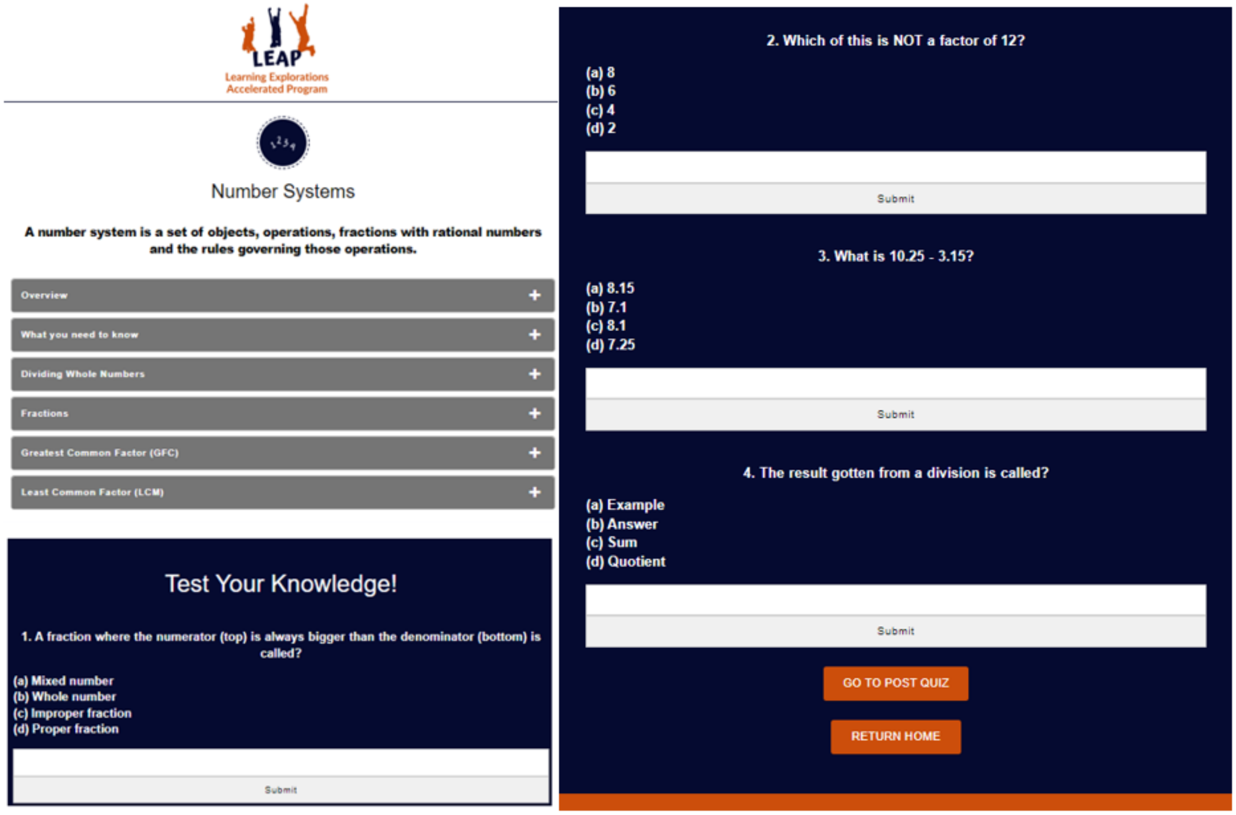


Figure 30: LEAP high-level design

When the “GO TO POST QUIZ” button is clicked, the student has to click to start the quiz. There are 10 questions and each of them are legible enough for the students to read. Each question has 4 options to choose from and when an option is chosen, it highlights it with a green color if correct. If that response is incorrect, it highlights it with a red color and the correct one with a green color. This way, the student is immediately notified about their mistakes. At the end of the quiz, the final score is displayed as shown below. Depending on the score of the student, they will advance to the next lesson or will be redirected to a lesson to take to help them with pre-requisite knowledge of the concepts.

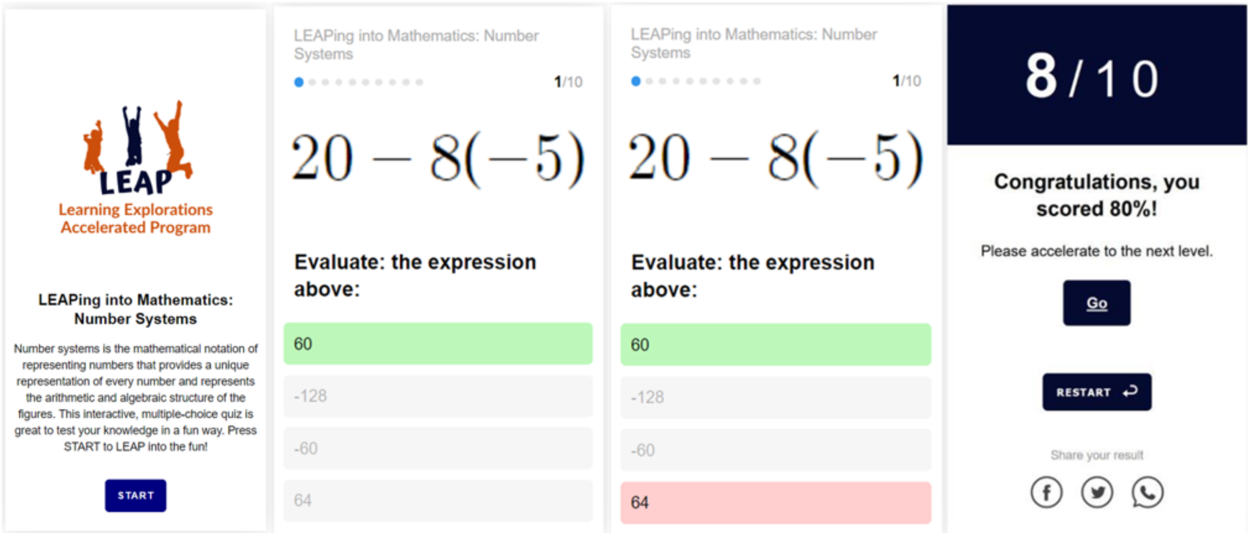


Figure 31: Post Quiz

5.8 LEAP Architecture

This consists of the FERN stack (for quizzes) and the ASP.NET architecture (front end).

5.8.1 FERN Architecture

1. Firebase (F):

   - Purpose: Firebase serves as the data storage and management system for LEAP. It's a NoSQL database, which means it's highly adaptable and excels at handling unstructured or semi-structured data.

   - Function: Firebase is responsible for storing and retrieving data used by the application. This data can include user information, quiz questions and answers, and more. It communicates with the back-end through a set of APIs, allowing the back-end to interact with and manipulate the data stored in Firebase.

2. Express (E):

- Purpose: Express is the backbone of the back-end in the FERN architecture.
- Function: It is a web framework for Node.js, which provides a robust and flexible foundation for building the server-side components of the application. The back-end handles tasks like user authentication, data processing, and responding to front-end requests.

3. React (R):

- Purpose: React is responsible for the user interface and the interactive elements of the LEAP application.
- Function: It creates the user-facing part of the application that users directly interact with. React is especially well-suited for building dynamic, responsive, and interactive web applications. It communicates with the back-end via a set of APIs to request and update data, ensuring a seamless user experience.

4. Node (N):

- Purpose: Node is the core of the back-end, handling the business logic and data processing for LEAP.
- Function: It communicates with the Firebase database and other external services through APIs. Node.js is known for its speed and scalability, making it an excellent choice for the back-end of applications like LEAP. It processes user requests, communicates with the database, performs calculations, and ensures the overall functionality of the system.

The FERN architecture, with its components Firebase, Express, React, and Node, forms the foundation of the LEAP application, allowing for efficient data storage, back-end logic, and user interaction. This combination of technologies helps create a robust and user-friendly environment for quiz-related activities within LEAP.

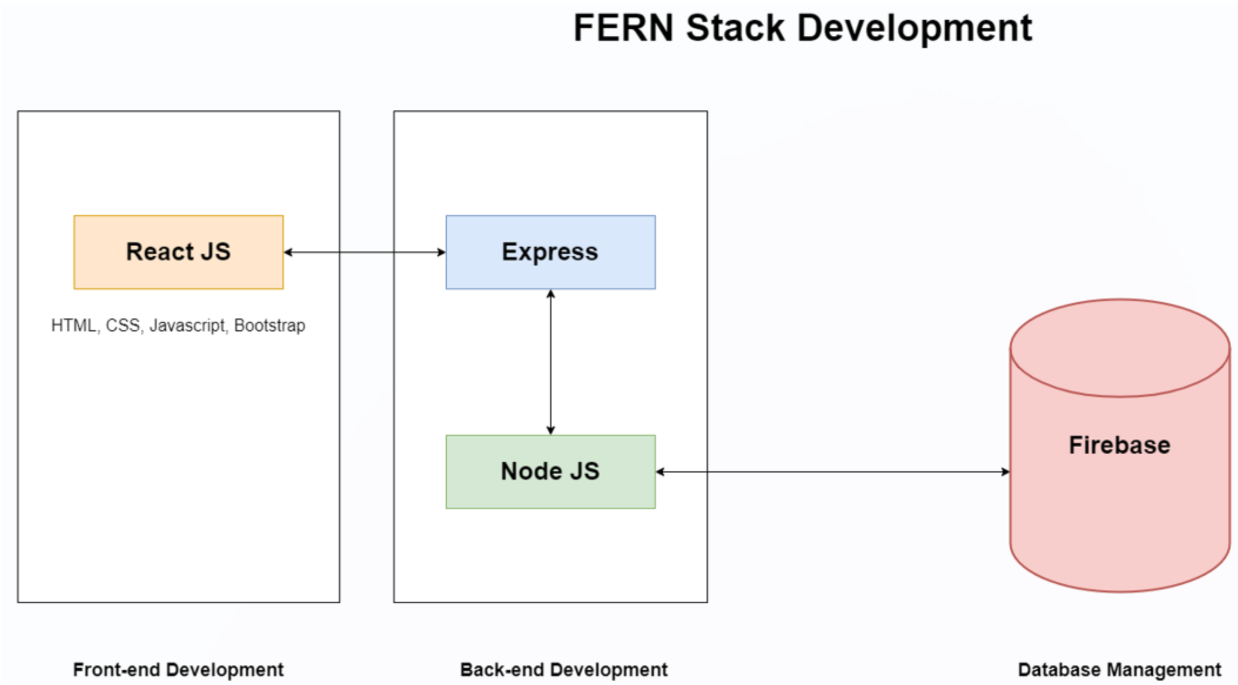


Figure 32: FERN stack development

5.8.2 ASP.NET Architecture

The front-end interface of LEAP was constructed using the ASP.NET MVC (Model-View-Controller) architecture, a powerful and versatile framework for creating and managing web features. Let's delve into a more detailed explanation of the MVC 5 architecture in the context of LEAP:

1. Model: This component deals with application data and its behavior. In the case of LEAP, the Model handles crucial tasks related to data management and business logic. For instance, it connects to a third-party vendor, Okta, to manage authentication and authorization. Okta, a prominent cloud-based identity and access management provider, enhances LEAP's security capabilities by facilitating role assignments, permissions, and other security-related functions.

2. View: The View in ASP.NET MVC represents the HTML markup that is presented to the end users. In LEAP, the View component plays a vital role in rendering and displaying the online learning content, which includes text, images, videos, and other educational materials. This content is designed using a combination of HTML, CSS, and JavaScript, offering a high degree of customization and flexibility.

3. Controller: The Controller serves as the intermediary between the View and the Model. In LEAP, the Controller is responsible for orchestrating various Views, such as navigating through lesson pages, managing user interactions, and working with the Model to ensure the smooth functioning of the application.

The combination of these three components, Model, View, and Controller, within the ASP.NET MVC architecture establishes a robust foundation for LEAP as a scalable and dependable Learning Management System (LMS).

In summary, the utilization of the ASP.NET MVC architecture empowers LEAP to provide a solid, adaptable, and secure platform for online learning. This framework facilitates the effective management of learning content, user interactions, and authentication processes, contributing to LEAP's capability as a reliable and scalable LMS.

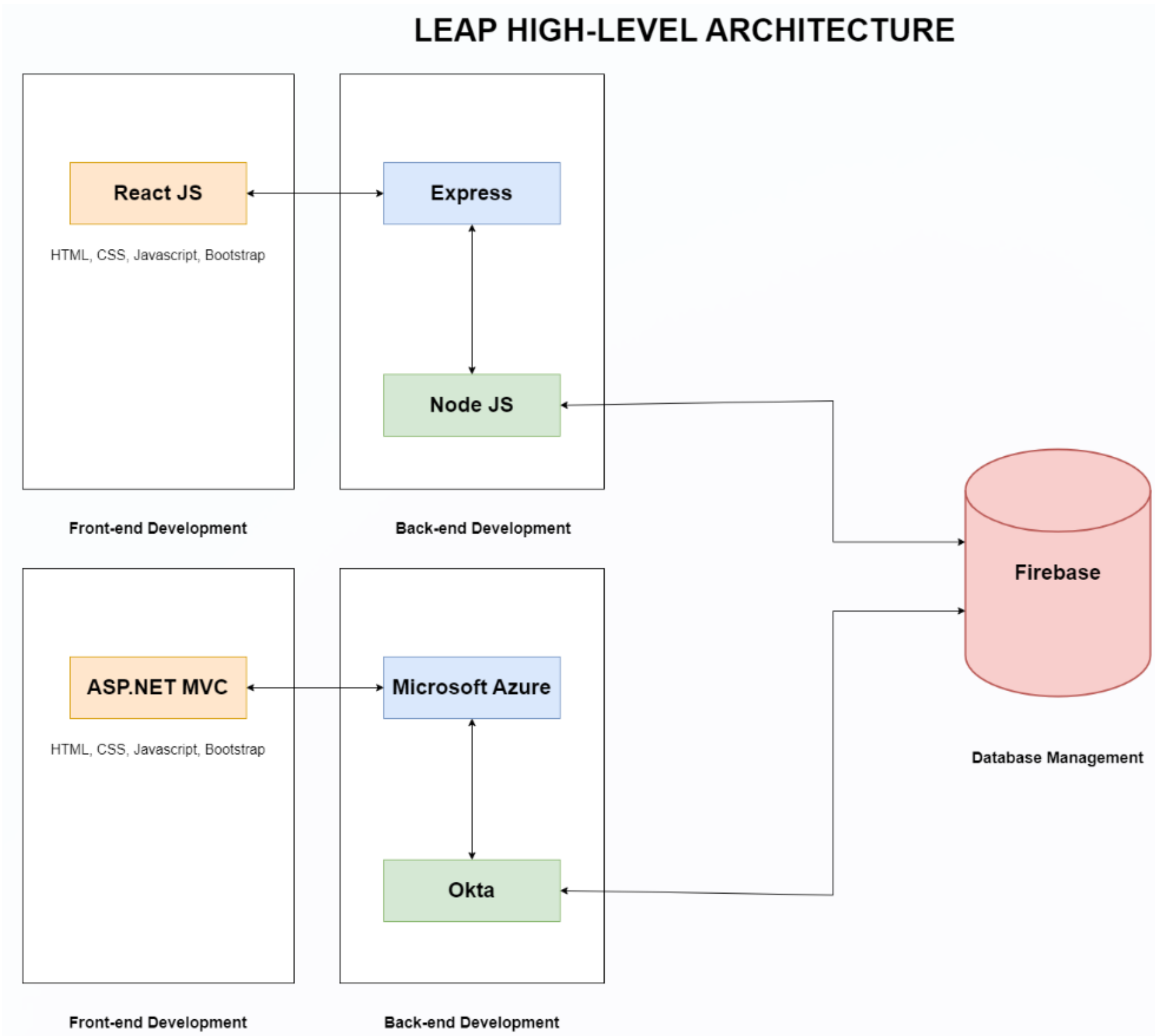


Figure 33: LEAP high-level architecture

5.9 Functional Requirements

5.9.1 Requirements for the Teacher

1. The application allows the teacher to be authenticated by signing in with username and password.

2. The application enables the teacher to create the course lessons, exams, and homework for the students.
3. The application enables teachers to duplicate a course framework into another for easier and faster course creation.
4. The application allows the teacher to edit fields in the course such as the course name, description, logo, upload files, save, delete, publish, start date, etc.
5. The application enables the teacher to update profile settings such as passwords, profile picture, and “About me” description.
6. The application enables the teacher to see the homework and exams grades for all students and their learning progress.
7. The application informs the teacher about a weekly progress of each student, their strengths, and weaknesses.
8. The application informs the teachers which students completed assigned work, students that are active and inactive with classroom tasks and homework.
9. The application tracks daily attendance the teacher took and over the past weeks. This will help monitor lagging students and absentees that might need reinforcement.

5.9.2 Requirements for the Student

1. The application enables a verified student to be authenticated.

2. The application enables the student to navigate throughout the course content and study the uploaded materials in the application.
3. The application enables the student to access and complete the assigned work.
4. The application allows the user to view grades after completing an assignment and exam.
5. The application enables the student to view the progress of an ongoing assignment or exam to know how many questions are remaining to complete.
6. The application enables the user to interact with the system by text or tapping commands.
7. The application notifies the student if questions were skipped before the submission of an assigned work.
8. The application enables the student to change profile settings like avatar.
9. The application enables students to inform their teachers about their health challenges and family emergencies if it disrupts their learning.

5.9.3 Requirements for the Admin

The requirements for the "admin" are as follows:

1. Manage users e.g., assign teacher (include Modify/Delete Teacher), adding new students (include Modify/Delete Student).
2. Manage courses.

5.9.4 Use Case Diagram

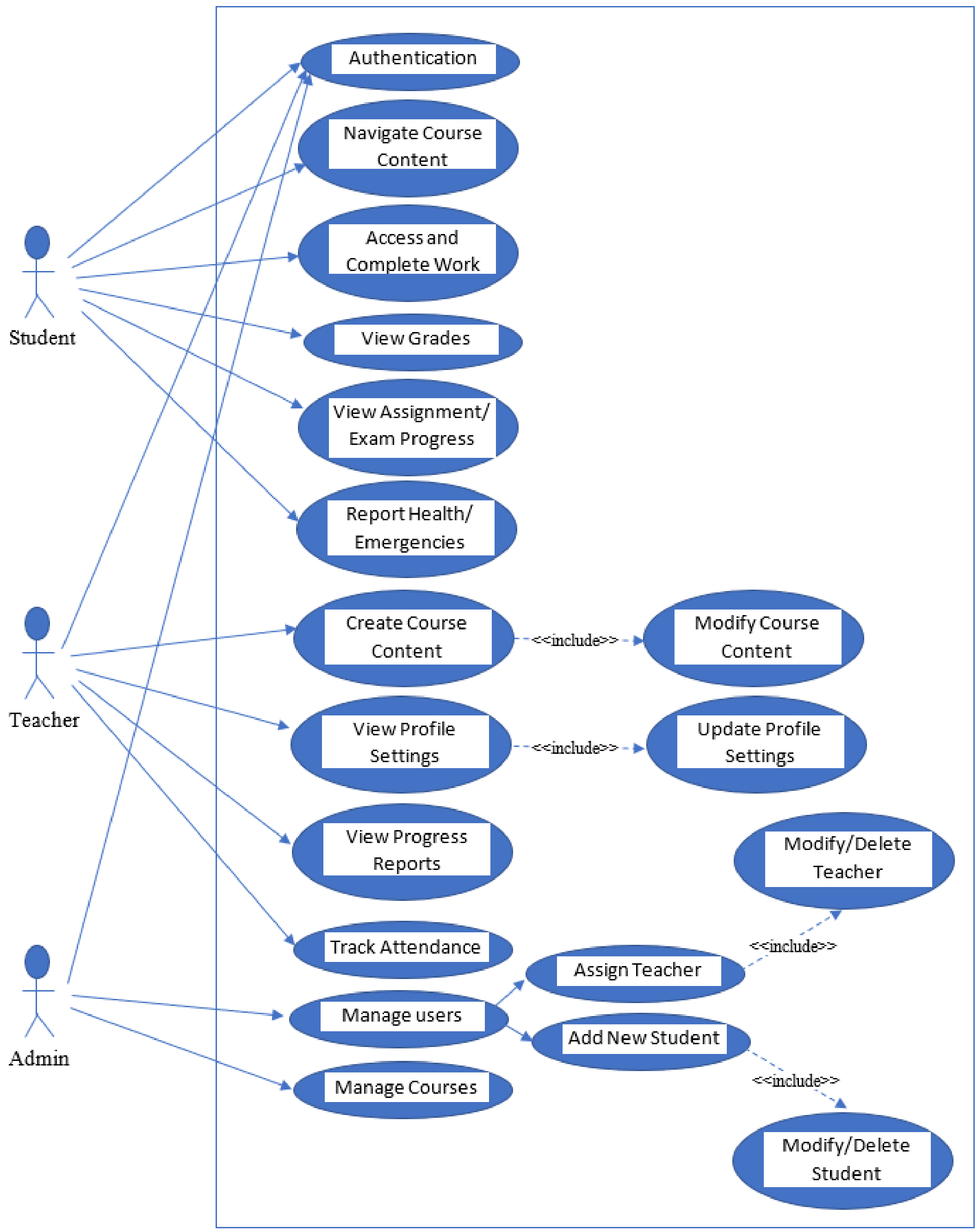


Figure 34: Use Case diagram for student, teacher and admin

Chapter 6 Usability Evaluation

6.1 Research Questions

This research aims to answer these questions as they pertain to the dissertation goals:

RQ1: Is LEAP perceived as easy to use?

To address this question, participants were asked 2 sub-questions:

i. *Perceived ease of use - Learning to operate the system would be easy for me.*
ii. *Perceived ease of use - I would find it easy to get the system to do what I want it to do.*

RQ2: Is LEAP easy to use?

To address this question, participants were asked 3 sub-questions:

i. *Ease of use - It is easy to use.*
ii. *Ease of use - It is simple to use.*
iii. *Ease of use - It is user friendly.*

RQ3: Does LEAP have an ease of learning?

To address this question, participants were asked 2 sub-questions:

i. *Ease of Learning - I learned to use it quickly.*
ii. *Ease of Learning - It is easy to learn to use it.*

RQ4: Does LEAP provide satisfaction?

To address this question, participants were asked 5 sub-questions:

i. *Satisfaction - I am satisfied with it.*

ii. *Satisfaction - I would recommend it to a friend.*

iii. *Satisfaction - It is fun to use.*

iv. *Satisfaction - It works the way I want it to work.*

v. *Satisfaction - It is wonderful.*

RQ5: Does LEAP help students accelerate their learning?

To address this question, participants were asked 2 sub-questions:

i. *Do you think this online framework will help students to accelerate their learning?*

ii. *Can you see yourself utilizing this software in your classroom?*

6.2 Participants

The participants for the usability study are participants that signed up to be contacted in future for follow-up experiment and task activities during the preliminary study. This was done by redirecting them to an online form to type in their email addresses. If they didn't wish to be contacted, they will close the online form to opt out. The online form was created on forms.app. It had only one field to type email address and to confirm the address. Out of the 24 AU students that participated in the informant design, only 7 of them participated in the application evaluation.

6.3 Results

These results present feedback from seven pre-service teachers after evaluating the software application. All responses are based on a five-point Likert scale. The Post survey is a web-based user interface evaluation which comprises Questionnaire for User Interface Satisfaction (QUIS), Perceived Usefulness and Ease of Use (PUEU), and Usefulness, Satisfaction, and Ease of use (USE).

The question:

"*What is your overall reaction to the application?*" is scaled at lowest (1: Terrible) and highest (5: Wonderful). The result shows that all responses (100%) say that it is Wonderful.

"What is your experience with the application?" is scaled at lowest (1: Difficult) and highest (5: Easy). The result shows that all responses (100%) say that it is Easy.

"What describes your emotion when using the application?" is scaled at lowest (1: Frustrating) and highest (5: Satisfying). The result shows that all responses (100%) say that it is Satisfying.

To answer the research question for Perceived ease of use, the teachers rated the system based on two sub-questions:

- Perceived ease of use - Learning to operate the system would be easy for me. Out of the 7 responses, 3 strongly agree while 4 somewhat agree. The average rating was 4.4.
- Perceived ease of use - I would find it easy to get the system to do what I want it to do. Out of the 7 responses, 3 strongly agree while 4 somewhat agree. The average rating was 4.4.

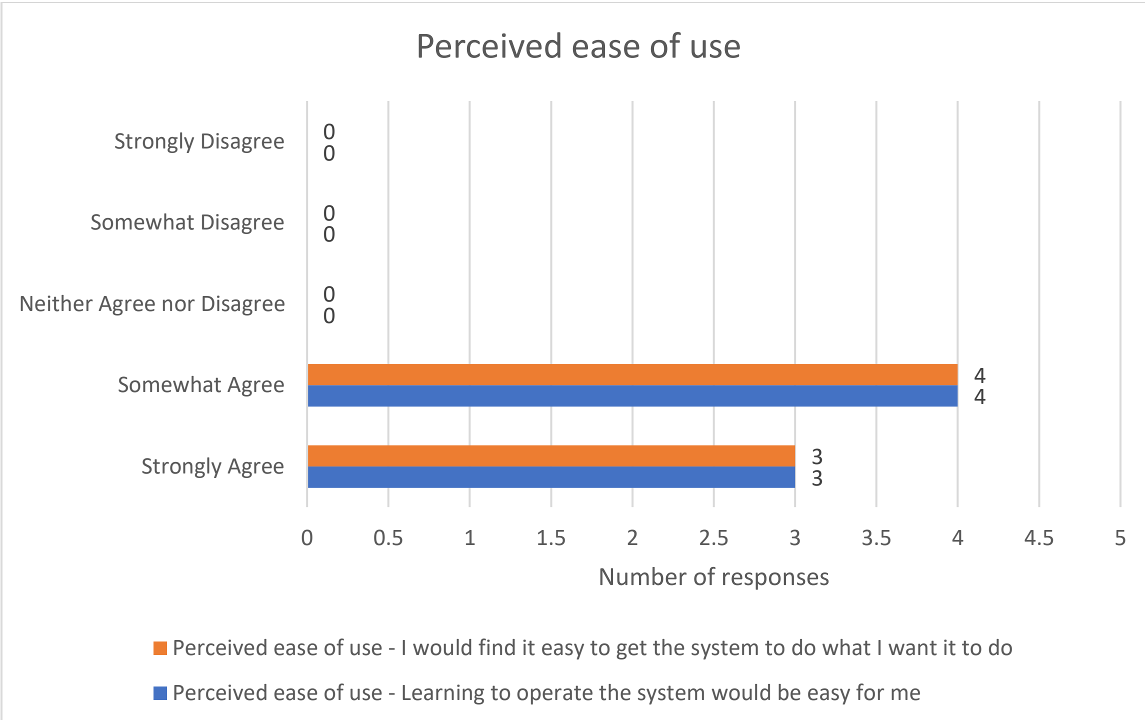


Figure 35: Results for Perceived ease of use

To answer the research question for Ease of use, the teachers rated the system based on three sub-questions:

- Ease of use - It is easy to use. Out of the 7 responses, 3 strongly agree while 4 somewhat agree. The average rating was 4.4.
- Ease of use - It is simple to use. Out of the 7 responses, 3 strongly agree while 4 somewhat agree. The average rating was 4.4.
- Ease of use - It is user friendly. Out of the 7 responses, 3 strongly agree while 4 somewhat agree. The average rating was 4.4.

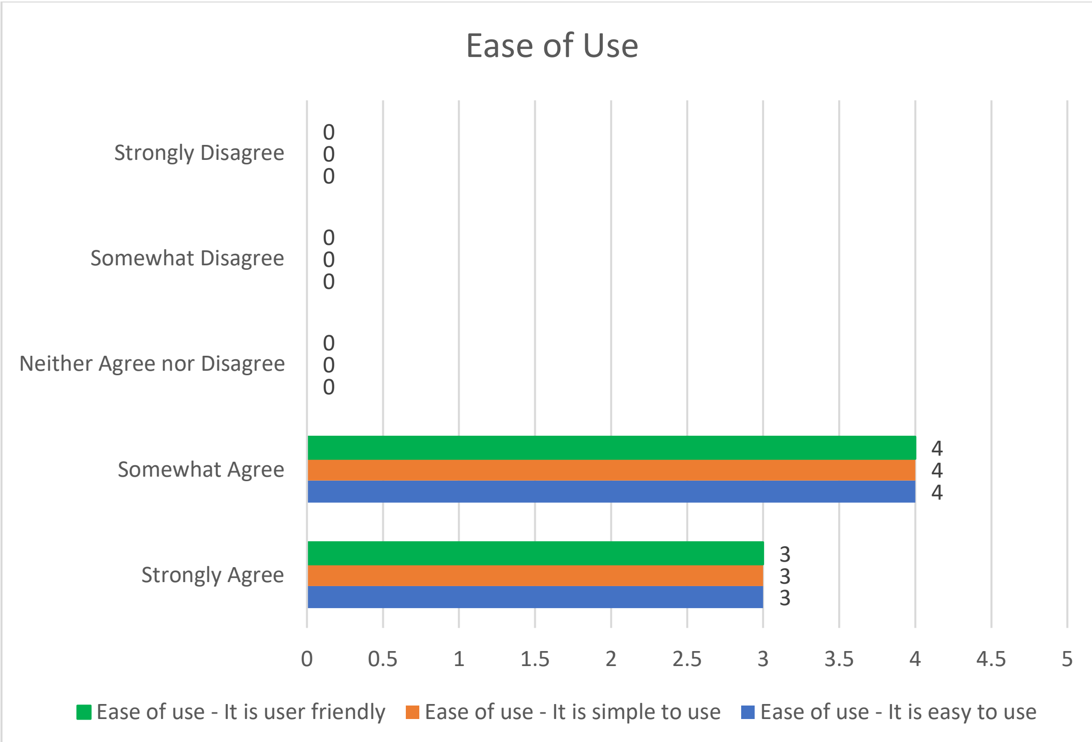


Figure 36: Results for Ease of use

To answer the research question for Ease of learning, the teachers rated the system based on two sub-questions:

- Ease of learning - I learned to use it quickly. Out of the 7 responses, 3 strongly agree while 4 somewhat agree. The average rating was 4.4.
- Ease of use - It is easy to learn to use it. Out of the 7 responses, 3 strongly agree while 4 somewhat agree. The average rating was 4.4.

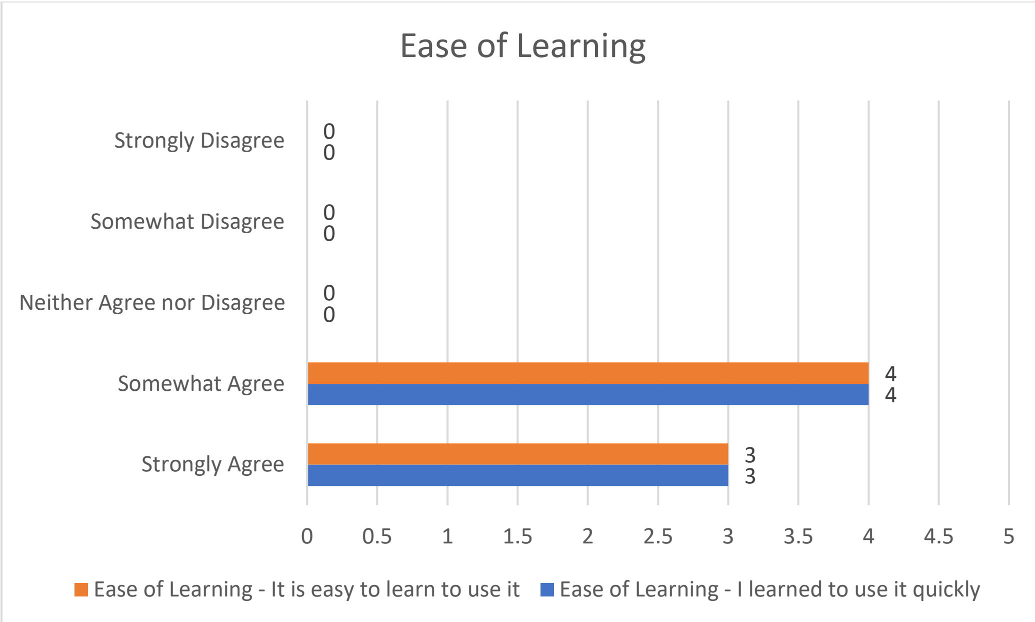


Figure 37: Results for Ease of Learning

To answer the research question for Satisfaction, the teachers rated the system based on five sub-questions:

- Satisfaction - I am satisfied with it. Out of the 7 responses, 3 strongly agree while 4 somewhat agree. The average rating was 4.4.
- Satisfaction - I would recommend it to a friend. Out of the 7 responses, 3 strongly agree while 4 somewhat agree. The average rating was 4.4.
- Satisfaction – It is fun to use. Out of the 7 responses, 2 strongly agree, 4 somewhat agree, and 1 neither agree nor disagree. The average rating was 3.6.
- Satisfaction – It works the way I want it to work. Out of the 7 responses, 3 strongly agree while 4 somewhat agree. The average rating was 4.4.
- Satisfaction - It is wonderful. Out of the 7 responses, 2 strongly agree, 4 somewhat agree, and 1 neither agree nor disagree. The average rating was 3.6.

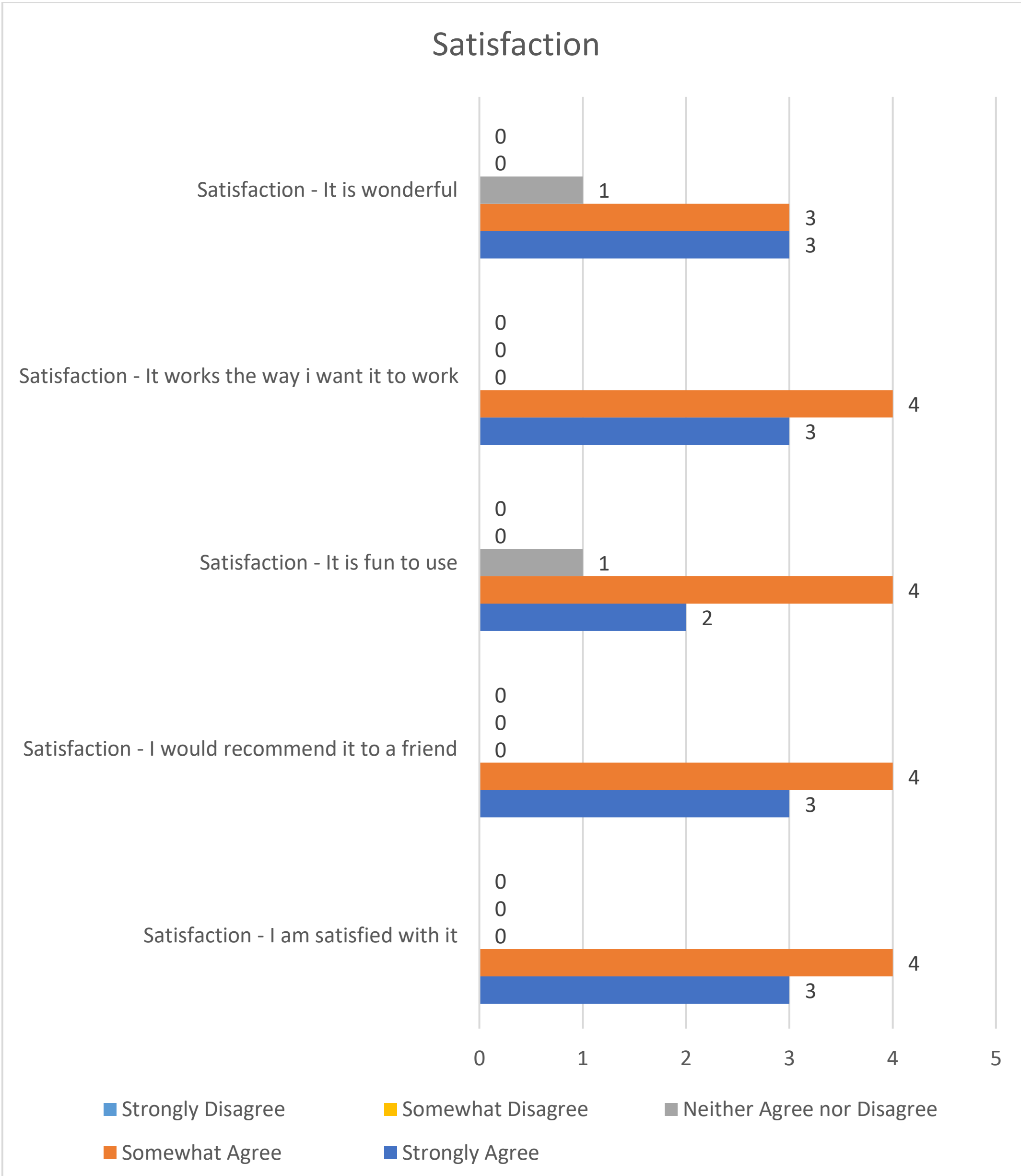


Figure 38: Results for Satisfaction

To answer the research question for accelerated learning, the teachers rated the system based on two sub-questions:

- Do you think this online framework will help students to accelerate their learning? Out of the 7 responses, 100% responded “Yes”.
- Can you see yourself utilizing this software in your classroom? Out of the 7 responses, 100% responded “Yes”.

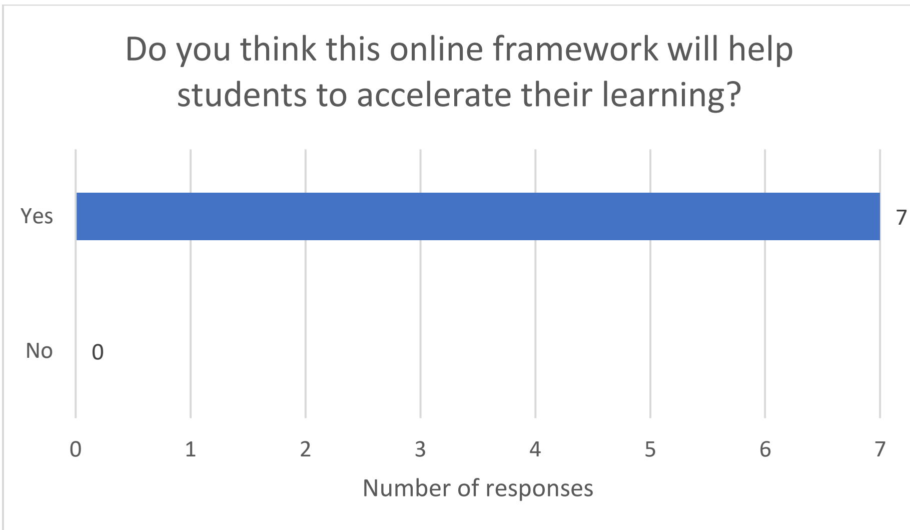


Figure 6.5: Results for accelerated learning

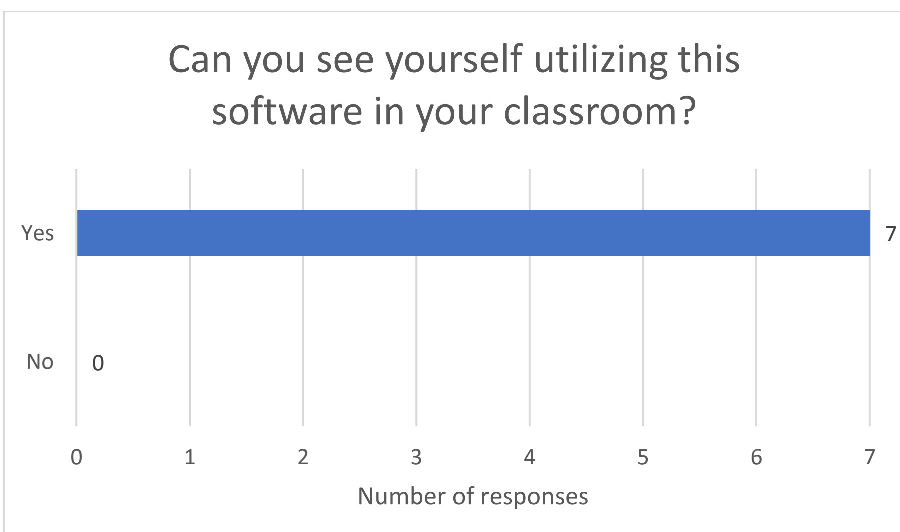


Figure 6.6: Results for software utilization in the classroom

Chapter 7 Conclusion and Future Work

7.1 Conclusion

The LEAP (Learning Explorations Accelerated Program) framework represents a transformative step in personalized education especially in Alabama public schools. By embracing the principles of user-centered design and leveraging advanced technology, LEAP ensures that learning is not only tailored to each student's unique abilities and needs but also remains dynamically responsive to their ongoing progress.

7.2 Future Work

Let pre-service and in-service teachers have the same columns (predictors) so that correlation can be carried out for:

- challenges teachers face (lack of engagement, lack of attendance, etc.) VS.
- areas of mathematics for reinforcement

I believe future analysis in this area will pave way to improve mathematics achievement for PreK-12 students in AL and the entire US. To ensure its effectiveness and relevance in a real-world educational setting, this predictive model can help educators better navigate the challenges they face.

Also, for deployment:

- integrate with LMS to provide real-time insights to educators.
- Create an API for the model to allow other systems and services to access its predictions.

For monitoring and feedback:

- Allow teachers or other users to provide feedback on the model's predictions.
- Periodically retrain the predictive model with fresh data.

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Appendices

Approved IRB documents

A. Exempt Application

AUBURN UNIVERSITY HUMAN RESEARCH PROTECTION PROGRAM (HRPP)

EXEMPT REVIEW APPLICATION

For assistance, contact: **The Office of Research Compliance (ORC)**
Phone: **334-844-5966** E-Mail: IRBAdmin@auburn.edu Web Address: http://www.auburn.edu/research/vpr/ohs
Submit completed form and supporting materials as one PDF through the IRB Submission Page
Hand written forms are not accepted. Where links are found hold down the control button (Ctrl) then click the link.

1. Project Identification **Today's Date: May 4, 2023**

Anticipated start date of the project: May 10, 2023 Anticipated duration of project: 1 Year

a. Project Title: Participatory Design & Development of Framework supporting Mathematics Acceleration

b. Principal Investigator (PI): Onyinye Rosemary Asogwa Degree(s): Click or tap here to enter text.
Rank/Title: Graduate Student Department/School: Computer Science and Software Engineering
Role/responsibilities in this project: **PI**
Preferred Phone Number: **4049606556** AU Email: ora0002@auburn.edu

Faculty Advisor Principal Investigator (if applicable): Cheryl Seals
Rank/Title: Professor Department/School: Computer Science and Software Engineering
Role/responsibilities in this project: **Co-I**
Preferred Phone Number: **3348446319** AU Email: sealscd@auburn.edu

Department Head: Hari Narayanan Department/School: Computer Science and Software Engineering Preferred Phone Number: **3348446312** AU Email: naraynh@auburn.edu
Role/responsibilities in this project: Click or tap here to enter text.

c. Project Key Personnel – Identify all key personnel who will be involved with the conduct of the research and describe their role in the project. Role may include design, recruitment, consent process, data collection, data analysis, and reporting. (To determine key personnel, see decision tree**).** *Exempt determinations are made by individual institutions; reliance on other institutions for exempt determination is not feasible. Non-AU personnel conducting exempt research activities must obtain approval from the IRB at their home institution.*

Key personnel are required to maintain human subjects training through CITI. Only for EXEMPT level research is documentation of completed CITI training NO LONGER REQUIRED to be included in the submission packet. NOTE however, **the IRB will perform random audits of CITI training records to confirm** reported training courses and expiration dates. Course title and expiration dates are shown on training certificates.

Name: Onyinye Rosemary Asogwa. Degree(s): Click or tap here to enter text.
Rank/Title: Graduate Student Department/School: Computer Science and Software Engineering
Role/responsibilities in this project: PI Asogwa will perform research prepare protocols, surveys and perform experiments and meet with participants.

AU affiliated? ☑ Yes ☐ No If no, name of home institution: Click or tap here to enter text.

- Plan for IRB approval for non-AU affiliated personnel? Click or tap here to enter text.

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- Do you have any known competing financial interests, personal relationships, or other interests that could have influence or appear to have influence on the work conducted in this project? ☐ Yes ☑ No - If yes, briefly describe the potential or real conflict of interest: Click or tap here to enter text.
- Completed required CITI training? ☑ Yes ☐ No If NO, complete the appropriate CITI basic course and update the revised Exempt Application form.
   - If YES, choose course(s) the researcher has completed: Conflicts of Interest in Research Involving Human Subjects (2025), Defining Research with Human Subjects (2025), History and Ethical Principles (2025), IRB # 2 Social and Behavioral Emphasis (2025), Internet Research (2025), Research in Public Elementary and Secondary Schools (2025)

Name: Dr. Cheryl Seals Degree(s): Click or tap here to enter text. Rank/Title: Professor
Department/School: Computer Science and Software Engineering
Role/responsibilities in this project: Co-I Seals will assist with research prepare protocols, surveys and assist experimental trials and meet with participants.

- AU affiliated? ☑ Yes ☐ No If no, name of home institution: Click or tap here to enter text.
- Plan for IRB approval for non-AU affiliated personnel? Click or tap here to enter text.
- Do you have any known competing financial interests, personal relationships, or other interests that could have influence or appear to have influence on the work conducted in this project? ☐ Yes ☑ No
- If yes, briefly describe the potential or real conflict of interest: Click or tap here to enter text.
- Completed required CITI training? ☑ Yes ☐ No If NO, complete the appropriate CITI basic course and update the revised EXEMPT application form.
- If YES, choose course(s) the researcher has completed: Conflicts of Interest in Research Involving Human Subjects (2024), IRB # 2 Social and Behavioral Emphasis (2025), History and Ethical Principles (2024), Responsible Conduct of Research for Social and Behavioral (2027).

Name: Click or tap here to enter text. Degree(s): Click or tap here to enter text.
Rank/Title: Choose Rank/Title Department/School: Choose Department/School
Role/responsibilities in this project: Click or tap here to enter text.

- AU affiliated? ☐ Yes ☐ No If no, name of home institution: Click or tap here to enter text.
- Plan for IRB approval for non-AU affiliated personnel? Click or tap here to enter text.
- Do you have any known competing financial interests, personal relationships, or other interests that could have influence or appear to have influence on the work conducted in this project? ☐ Yes ☐ No - If yes, briefly describe the potential or real conflict of interest: Click or tap here to enter text.
- Completed required CITI training? ☐ Yes ☐ No If NO, complete the appropriate CITI basic course and update the revised EXEMPT application form.
- If YES, choose course(s) the researcher has completed: Choose a course Expiration Date
  Choose a course Expiration Date

d. Funding Source – Is this project funded by the investigator(s)? Yes ☐ No ☒

Is this project funded by AU? Yes ☒ No ☐ If YES, identify source Click or tap here to enter text.

Is this project funded by an external sponsor? Yes ☐ No ☒ If YES, provide name of sponsor, type of sponsor (governmental, non-profit, corporate, other), and an identification number for the award.
Name: Click or tap here to enter text. Type: Click or tap here to enter text. Grant #: Click or tap here to enter text.

e. List other AU IRB-approved research projects and/or IRB approvals from other institutions that are associated with this project. Describe the association between this project and the listed project(s):
Click or tap here to enter text.

2. Project Summary

a. Does the study *TARGET* any special populations? Answer YES or NO to all.

Minors (under 18 years of age; if minor participants, at least 2 adults must be present during all research procedures that include the minors)	Yes ☐ No ☒
Auburn University Students	Yes ☐ No ☒
Pregnant women, fetuses, or any products of conception	Yes ☐ No ☒
Prisoners or wards (unless incidental, not allowed for Exempt research)	Yes ☐ No ☒
Temporarily or permanently impaired	Yes ☐ No ☒

b. Does the research pose more than minimal risk to participants? Yes ☐ No ☒

If YES, to question 2.b, then the research activity is NOT eligible for EXEMPT review. Minimal risk means that the probability and magnitude of harm or discomfort anticipated in the research is not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or test. 42 CFR 46.102(i)

c. Does the study involve any of the following? *If YES to any of the questions in item 2.c, then the research activity is NOT eligible for EXEMPT review.*

Procedures subject to FDA regulations (drugs, devices, etc.)	Yes ☐ No ☒
Use of school records of identifiable students or information from instructors about specific students.	Yes ☐ No ☒
Protected health or medical information when there is a direct or indirect link which could identify the participant.	Yes ☐ No ☒
Collection of sensitive aspects of the participant's own behavior, such as illegal conduct, drug use, sexual behavior or alcohol use.	Yes ☐ No ☒

d. Does the study include deception? Requires limited review by the IRB* Yes ☐ No ☒

3. MARK the category or categories below that describe the proposed research. Note the IRB Reviewer will make the final determination of the eligible category or categories.

☐ **1.** Research conducted in established or commonly accepted educational settings, involving normal educational practices. The research is not likely to adversely impact students' opportunity to learn or assessment of educators providing instruction. 104(d)(1)

☒ **2.** Research only includes interactions involving educational tests, surveys, interviews, public observation if at least ONE of the following criteria. (The research includes data collection only; may include visual or auditory recording; may NOT include intervention and only includes interactions). **Mark the applicable sub-category below (I, ii, or iii). 104(d)(2)**

☐ **(i)** Recorded information cannot readily identify the participant (directly or indirectly/ linked);

OR

- surveys and interviews: no children;
- educational tests or observation of public behavior: can only include children when investigators do not participate in activities being observed.

☐ **(ii)** Any disclosures of responses outside would not reasonably place participant at risk; **OR**

☒ **(iii)** Information is recorded with identifiers or code linked to identifiers and IRB conducts limited review; no children. **Requires limited review by the IRB.***

☐ **3.** Research involving Benign Behavioral Interventions (BBI)** through verbal, written responses including data entry or audiovisual recording from adult subjects who prospectively agree and ONE of the following criteria is met. (This research does not include children and does not include medical interventions. Research cannot have deception unless the participant prospectively agrees that they will be unaware of or misled regarding the nature and purpose of the research) **Mark the applicable sub-category below (A, B, or C).** 104(d)(3)(i)

☐ **(A)** Recorded information cannot readily identify the subject (directly or indirectly/ linked); **OR**

☐ **(B)** Any disclosure of responses outside of the research would not reasonably place subject at risk; **OR**

☐ **(C)** Information is recorded with identifies and cannot have deception unless participants prospectively agree. **Requires limited review by the IRB.***

☐ **4.** Secondary research for which consent is not required: use of identifiable information or identifiable bio-specimen that have been or will be collected for some other 'primary' or 'initial' activity, if one of the following criteria is met. Allows retrospective and prospective secondary use. **Mark the applicable sub-category below (i, ii, iii, or iv).** 104 (d)(4)

☐ **(i)** Bio-specimens or information are publicly available;

☐ **(ii)** Information recorded so subject cannot readily be identified, directly or indirectly/linked investigator does not contact subjects and will not re-identify the subjects; **OR**

☐ **(iii)** Collection and analysis involving investigators use of identifiable health information when us is regulated by HIPAA "health care operations" or "research" or "public health activities and purposes" (does not include bio-specimens (only PHI and requires federal guidance on how to apply); **OR**

☐ **(iv)** Research information collected by or on behalf of federal government using government generated or collected information obtained for non-research activities.

☐ **5.** Research and demonstration projects which are supported by a federal agency/department AND designed to study and which are designed to study, evaluate, or otherwise examine: (i)public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or service under those programs. (must be posted on a federal web site). 104.5(d)(5) (must be posted on a federal web site)

☐ **6.** Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives and consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture. The research does not involve prisoners as participants. 104(d)(6)

**Limited IRB review – the IRB Chair or designated IRB reviewer reviews the protocol to ensure adequate provisions are in place to protect privacy and confidentiality.*

***Category 3 – Benign Behavioral Interventions (BBI) must be brief in duration, painless/harmless, not physically invasive, not likely to have a significant adverse lasting impact on participants, and it is unlikely participants will find the interventions offensive or embarrassing.*

**** Exemption categories 7 and 8 require broad consent. The AU IRB has determined the regulatory requirements for legally effective broad consent are not feasible within the current institutional infrastructure. EXEMPT categories 7 and 8 will not be implemented at this time.*

4. **Describe the proposed research including who does what, when, where, how, and for how long, etc. a.** Purpose

The proposed research aims to research technological integration in the classroom for Pre-K - 12th grade. Research shows that the COVID-19 pandemic had a great impact in younger elementary grades in areas of mathematics and reading, and under-represented population. This proposed research aims to identify the areas of unfinished learning, provide accelerated academies, content reinforcement, and enhance formal and informal education. This research will work with Pre-K – 12th grade teachers to create a pedagogical framework to help accelerate teaching and learning in the classroom and at home.

Phase One – Informant Design

The teachers will respond to an online survey which will sent via Qualtrics or Survey Monkey which will collect open-ended questions, and a set of single-choice questions that will help identify the course topics, content areas for reinforcement, and other features necessary for classroom engagement. In this research, we (who - i.e., principal and co-investigator) will perform this preliminary analysis to inform the design of our applications. We will collect information from (who - i.e., teachers) about what (i.e., their methods and what were some of the problems that they encountered with math instruction during the pandemic and general areas that students have problems with) and utilize this information to develop our application.

Phase Two – Evaluation Study

After we (i.e., PI and CoI) have developed our application, we will test it with participants (i.e., teachers). We will perform a pre-questionnaire of participants (5-10 minutes), followed by use of the application (20-40 minutes), and this session will end with a post-questionnaire (5-10 minutes) to ascertain the usefulness, effectiveness, and usability of the application to test the hypothesis that this application will potentially improve math readiness for their students. We want to use identifiers to match the amount of change per individual related to the experiment.

For those that continue from Phase1 – Phase2, they will reuse a generated 5digit code that is assigned to the participant, and we will request the user reuse this code for Phase2 of the experiment (code is 3 letters (initials) followed by 2-digits (last two-digits of birth year). The collected data will be analyzed quantitatively and qualitatively to exact the necessary information for building and refining a pedagogical framework to enhance mathematics teaching and learning.

b. Participant population, including the number of participants and the rationale for determining number of participants to recruit and enroll. Note if the study enrolls minor participants, describe the process to ensure more than 1 adult is present during all research procedures which **include the minor**.

The participants will be Pre-K – 12th grade teachers and we will recruit using email to teachers that we have worked with on prior projects, opportunistic sampling, and snowball recruiting. We will provide an example recruitment email in the IRB appendix. Here are the steps for the participants:

1. Preliminary Survey to discover about population (teachers) and their and students needs

Application Development

2. Pre-Questionnaire with Teachers
3. Task Driven Review of Software Application
4. Post-Questionnaire with Teachers

c. Recruitment process. Address whether recruitment includes communications/interactions between study staff and potential participants either in person or online. *Submit a copy of all recruitment materials.* We will send them a survey link: https://auburn.qualtrics.com/jfe/form/SV_cHonxbqZOGDIDMq

d. Consent process including how information is presented to participants, etc. The information letter will be used for consent.

e. Research procedures and methodology
The teachers will respond to the survey and we will work with them to create a pedagogical framework.

f. Anticipated time per study exercise/activity and total time if participants complete all study activities.
Duration of time needed to complete the pre-survey is 10 – 20 minutes and post-survey is 5 – 10 minutes.

g. Location of the research activities. The research will be done online.

h. Costs to and compensation for participants? If participants will be compensated describe the amount, type, and process to distribute.
There will be no compensations.

i. Non-AU locations, site, institutions. *Submit a copy of agreements/IRB approvals.* Click or tap here to enter text.

j. Additional relevant information. Click or tap here to enter text.

5. Waivers
Check applicable waivers and describe how the project meets the criteria for the waiver.

☐ Waiver of Consent (Including existing de-identified data)
☒ Waiver of Documentation of Consent (Use of Information Letter, rather than consent form requiring signatures)

☐ Waiver of Parental Permission (in Alabama, 18 years-olds may be considered adults for research purposes) **a.**

Provide the rationale for the waiver request.

We updated the Informed Consent to an Information Letter through removing unneeded signatures. The information collected will be anonymous for those who complete pre-survey only. For those that continue the experience we will have a code that links pre-to-post survey results (i.e., data will be collected and to maintain confidentiality, data will be collected on Qualtrics servers and will also be saved on AU BOX. Only Primary Investigator and the Co-Investigator have access to the survey results).

6. Describe the process to select participants/data/specimens. If applicable, include gender, race, and ethnicity of the participant population.
The participants will be Pre-K – 12th grade teachers and we hope to recruit a vast population with regards to gender, race, ethnicity. The surveys will be distributed online via Qualtrics with this link:
https://auburn.qualtrics.com/jfe/form/SV_cHonxbqZOGDIDMq

7. Risks and Benefits

7a. Risks - Describe why none of the research procedures would cause a participant either physical or psychological discomfort or be perceived as discomfort above and beyond what the person would experience in daily life (minimal risk).

There are no risks associated with this research.

7b. Benefits – Describe whether participants will benefit directly from participating in the study. If yes, describe the benefit. And, describe generalizable benefits resulting from the study.

The teachers may have a better teaching experience and the students may advance in learning.

8. Describe the provisions to maintain confidentiality of data, including collection, transmission, and storage. Identify platforms used to collect and store study data. *For EXEMPT research, the AU IRB recommends AU BOX or using an AU issued and encrypted device. If a data collection form will be used, submit a copy.*

The survey data will be securely stored on Qualtrix servers. Only Primary Investigator and Co-Investigators have access to the survey results.

a. If applicable, submit a copy of the data management plan or data use agreement.

9. Describe the provisions included in the research to protect the privacy interests of participants (e.g., others will not overhear conversations with potential participants, individuals will not be publicly identified or embarrassed).

The survey data will be securely stored on Qualtrix servers. Only Primary Investigator and Co-Investigators have access to the survey results.

10. Additional Information and/or attachments.

In the space below, provide any additional information you believe may help the IRB review of the proposed research. If attachments are included, list the attachments below. Attachments may include recruitment materials, consent documents, site permissions, IRB approvals from other institutions, data use agreements, data collection form, CITI training documentation, etc.

Printed version of the online survey. Online survey can be found here:
https://auburn.qualtrics.com/jfe/form/SV_cHonxbqZOGDIDMq

Required Signatures *(If a student PI is identified in item 1.a, the EXEMPT application* *must* *be re-signed and updated at* *every* *revision by the student PI and faculty advisor. The signature of the department head is required* *only* *on the initial submission of the EXEMPT application, regardless of PI. Staff and faculty PI submissions require the PI signature on all version, the department head signature on the original submission)*

Signature of Principal Investigator:____________________ **Date:** 05/04/2023

Signature of Faculty Advisor (If applicable):____________________ **Date:** 05/04/2023

Signature of Dept. Head: N. Hari Narayanan **Date:** 2/25/22

Version Date: 5/4/2023

B. Information Letter

AUBURN UNIVERSITY
SAMUEL GINN COLLEGE OF ENGINEERING
DEPARTMENT OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

(NOTE: DO NOT AGREE TO PARTICIPATE UNLESS AN APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

INFORMATION LETTER
for a Research Study entitled
"Participatory Design & Development of Framework supporting Mathematics Acceleration"

You are invited to participate in a research study to research technological integration in the classroom for Pre-K - 12th grade and the lingering effect of COVID on learning. The study is being conducted by PhD candidate, Onyinye Rosemary Asogwa, under the direction of Dr. Cheryl Seals in the Auburn University Department of Computer Science and Software Engineering. You are invited to participate because you are age 19 or older and are a Pre-K - 12th grade school teacher.

What will be involved if you participate? Phase One - Informant Design

If you decide to participate in this research study, you will be asked to complete an online survey about your opinion and experience with the integration of technology in the classroom and the effect of COVID in your teaching and students' learning. Your commitment time for this preliminary survey will be approximately 10 - 20 minutes.

Phase Two - Application Evaluation.

If you elect to be a member of the follow-up experiment and task activities, you can indicate that you want to continue this experience (i.e., by leaving your contact email on a separate form that does not capture any of your identifying information). At completion of the initial survey, the participant will be redirected to an online form to type in email address. If they don't wish to be contacted, they can opt out by closing the tab containing the form. If they wish to continue, the evaluators will contact them for Phase 2 when we are ready to get feedback on the student acceleration application design/development and/or evaluation. Participants will perform pre-questionnaire, evaluate application, and complete post-questionnaire. There is also a planned retrospective interview that is optional. Post-Questionnaire take approximately 5–10-minutes.

Are there any risks or discomforts? There are no risks or discomforts involved.

Are there any benefits to yourself or others? The teachers may have a better teaching experience and the students may advance in learning. The information provided will give us insight into teacher perceptions of student learning and the effects of COVID on loss of learning, what types of technology will be best supportive of their students, also specific suggestions on needed content to support their students. From the literature we have discovered that different demographics of students have different technological and educational needs, and we plan to tailor this application for students in our service area and state. We want to provide application that will support students and teachers from under resourced schools and counties.

Will you receive compensation for participating? There is no compensation for participation.

Are there any costs? There are no costs to participate in the research.

If you change your mind about participating, you can withdraw at any time by stopping the survey.

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Version Date (date document created): 05/04/2023

AUBURN UNIVERSITY
SAMUEL GINN COLLEGE OF ENGINEERING
DEPARTMENT OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

Any data obtained in connection with this study will remain anonymous. The study will take place via an online survey. Only the investigators of this research will have access to the data obtained. Information collected through your participation may be used in a scientific paper, presentation, poster, or thesis.

If you have questions about this study, please contact Onyinye Rosemary Asogwa at ora0002@auburn.edu or Dr. Cheryl Seals at sealscd@auburn.edu.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334) 844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION ABOVE, YOU MUST DECIDE IF YOU WANT PARTICIPATE IN THIS RESEARCH PROJECT. IF YOU DECIDE TO PARTICIPATE, PLEASE CLICK ON THE LINK BELOW. YOU MAY PRINT A COPY OF THIS LETTER TO KEEP.

05/04/2023
Investigator Date

Onyinye Rosemary Asogwa
Printed Name

Co-Investigator Date 05/04/2023
Dr. Cheryl Seals
Printed Name

LINK TO SURVEY

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Protocol # 22-106 EX 2209

Version Date (date document created): 05/04/2023

C. Recruitment Email

RECRUITMENT EMAIL

Dear Teacher,

Thank you for taking the time to read this email. My name is Onyinye Rosemary Asogwa - a Ph.D. student studying Computer Science at Auburn University, Auburn, AL. Together with my advisor, Dr. Cheryl Seals, we are carrying out a survey on PreK - 12th grade school teachers to evaluate the integration of technology in the classrooms and how COVID has affected teaching and learning in your educational settings.

Your participation is completely voluntary. If you decide to participate in this research study, you will be asked to complete an online survey about your opinion and experience with the integration of technology in the classroom and the effect of COVID in your teaching and students' learning. Your commitment time for this survey will be approximately 10 - 20 minutes.

If you have questions about this study, please contact Onyinye Rosemary Asogwa at ora0002@auburn.edu or Dr. Cheryl Seals at sealscd@auburn.edu.

You can find the full Information Letter attached below.

SURVEY LINK

https://auburn.qualtrics.com/jfe/form/SV_cHonxbqZOGDIDMq

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Protocol # 22-106 EX 2209

D. Pre-Survey

Pre-Survey for Teachers

Hello! You are invited to participate in a research study to evaluate the integration of technology in the classrooms and understand the lingering effects of COVID on teaching and learning in your educational settings. The study is being conducted by Ph.D. candidate, Onyinye Rosemary Asogwa, under the direction of Dr. Cheryl Seals in the Auburn University Department of Computer Science and Software Engineering. You are invited to participate because you are age 19 or older and are a Pre-K - 12th grade school teacher.

What will be involved if you participate?
Phase One - Informant Design. If you decide to participate in this research study, you will be asked to complete an online survey about your opinion and experience with the integration of technology in the classroom and the effect of COVID on your teaching and students' learning. Your commitment time for this preliminary survey will be approximately 10 - 20 minutes.

Phase Two - Application Evaluation. If you elect to be a member of the follow-up experiment and task activities, you can indicate that you want to continue this experience (i.e., by leaving your contact email on a separate form that does not capture any of your identifying information). At the completion of the initial survey, the participant will be redirected to an online form to type in an email address. If they don't wish to be contacted, they can opt-out by closing the tab containing the form. If they wish to continue, the evaluators will contact them for Phase 2 when we are ready to get feedback on the student acceleration application design/development and/or evaluation. Participants will perform a pre-questionnaire, evaluate the application, and complete the post-questionnaire. The post Questionnaire takes approximately 5–10 minutes.

Are there any risks or discomforts? There are no risks or discomforts involved.

Are there any benefits to yourself or others? The teachers may have a better teaching experience and the students may advance in learning. The information provided will give us insight into teacher perceptions of student learning and the effects of COVID on the loss of learning, what types of technology will be best supportive of their students, also specific suggestions on needed content to support their students. From the literature, we have discovered that different demographics of students have different technological and educational needs, and we plan to tailor this application for students in our service area and state. We want to provide an application that will support students and teachers from under-resourced schools and counties.

Will you receive compensation for participating? There is no compensation for participation.

Are there any costs? There are no costs to participate in the research.

If you change your mind about participating, you can withdraw at any time by stopping the survey If you have questions about this study, please contact Onyinye Rosemary Asogwa at ora0002@auburn.edu or Dr. Cheryl Seals at sealscd@auburn.edu.

Any data obtained in connection with this study will remain confidential. The study will take place via an online survey. Collected data with Auburn Qualtrix will be stored in Auburn Box. Only the investigators of this research will have access to the data obtained.

If you have questions about this study, please contact Onyinye Rosemary Asogwa at ora0002@auburn.edu or Dr. Cheryl Seals at sealscd@auburn.edu.

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Protocol # 22-106 EX 2209

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334) 844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

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04/28/2023 to -------------
Protocol # 22-106 EX 2209

HAVING READ THE INFORMATION ABOVE, YOU MUST DECIDE IF YOU WANT TO PARTICIPATE IN THIS RESEARCH PROJECT. IF YOU DECIDE TO PARTICIPATE, PLEASE CLICK ON THE LINK

Page Break

Instruction

Please tell us about yourself.

+ Add page break

Q1 *

What is your sex?

- ○ Male
- ○ Female
- ○ Prefer not to answer

Q2 *

How old are you?

- ○ Under 25 years
- ○ 25 - 29 years
- ○ 30 - 39 years
- ○ 40 - 49 years
- ○ 50 - 59 years
- ○ 60+

Q3 *

Are you of Hispanic or Latino Origin?

- ○ Yes
- ○ No

Q4 *

Which best describes your race?

- ○ American Indian or Alaska Native
- ○ Asian
- ○ Black or African American
- ○ Native Hawaiian or Other Pacific Islander
- ○ White

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Q5

What is the highest level of education you have completed?

- ○ Associate's degree
- ○ Bachelor's degree
- ○ At least one year of course work beyond a bachelor's degree but not a graduate degree
- ○ Master's degree
- ○ Completed a PhD, MD, or other advanced professional degree

Q6

Are you a certified teacher?

- ○ Yes
- ○ No

Q7

Prior years of Teaching Experience?

- ○ 0 - 2 years
- ○ 3 - 5 years
- ○ 6 - 10 years
- ○ 11 - 15 years
- ○ 16 - 20 years
- ○ 21 -25 years
- ○ 26 years or more

Page Break

Instruction

Please tell us about your classroom experience.

Q8

What class do you teach?

Pre-K

Q9

How many students do you have in this class?

- ○ 0 - 9
- ○ 10 - 19
- ○ 20 - 29
- ○ 30 or more

Q10

What is your state?

- ○ AL
- ○ GA
- ○ TN
- ○ MS
- ○ LA
- ○ FL
- ○ Other

Q11

What is your **AL** school district?

Please select school district

Q12

What is the name of your school? *This result won't be published as stated and approved by our IRB. Strictly for our own records for potential future collaboration.*

Q13 *

Which technology do you use in your classroom to support student learning?
CHECK ALL THAT APPLY

- ☐ TV
- ☐ Desktop Computers
- ☐ Laptops
- ☐ Tablets
- ☐ Phones
- ☐ Smart Board
- ☐ Other (please specify)

Q14 *

How do your students use technology?
CHECK ALL THAT APPLY

- ☐ Watching videos on YouTube and/or other streaming apps
- ☐ Performing a classroom activity
- ☐ Playing interactive games
- ☐ Listening to music
- ☐ Other (please specify)

Q15 *

How often do your students use technology **IN A DAY**?

- ○ Less than 1 hour in a day
- ○ 1 - 3 hours in a day
- ○ 3 - 5 hours in a day
- ○ Greater than 5 hours

Q16 *

How often do your students use these technologies **IN A WEEK**?

- ○ Less than 1 hour per week
- ○ 1 - 3 hours per week
- ○ 3 - 5 hours per week
- ○ Greater than 5 hours

Q17 *

Do you use any digital assessment technologies (e.g. Socrative, Kahoot, Google Forms, Plickers, Teaching Strategies, etc.) to assess your students' learning?

- No
- Yes (please specify)

Q18 *

Do you think technology help students learn a concept faster?

- No
- Yes
- Maybe (please explain)

Q19 *

Do you think technology will help all students think and learn more deeply?

- No
- Yes
- Maybe (please explain)

Q20 *

Do you think that integrating technology into your curriculum is important for student success?

- No
- Yes
- Maybe (please explain)

Q21 *

Do you think the students should use more/less technology tools in the classroom?

- Yes, more tech
- No, less tech
- Maybe (please explain)

Q22 *

Do you sometimes think that technology in the classroom is a distraction?

- ○ No
- ○ Yes
- ○ Maybe (please explain)

Q23 *

Which mode of instruction do you utilize most regularly for classroom delivery?
CHECK ALL THAT APPLY

- ☐ Teacher-directed whole class
- ☐ Teacher-directed small group
- ☐ Student-directed small group
- ☐ Individual (independent) work e.g., reading
- ☐ Computer or technology-based learning

Q24 *

How are your students mostly engaged in learning?
CHECK ALL THAT APPLY

- ☐ Teacher-directed whole class
- ☐ Teacher-directed small group
- ☐ Student-directed small group
- ☐ Individual (independent) work e.g., reading
- ☐ Computer or technology-based learning

Q25 *

Where do your students mainly use computers? Choose one.

- ○ Classroom
- ○ Computer lab or library

Q26 *

Which setting best describes the student/computer ratio in your classroom?

- ○ No computers in the classroom; students use computers in a lab
- ○ Only computer in classroom is for teacher use; students use computer s in a lab
- ○ 1 classroom computer for every 4 - 6 students
- ○ 1 classroom computer for every 2 - 3 students
- ○ 1 classroom computer for every student

Q27 *

Do your students have 1:1 tablet (one tablet per student) in the classroom?

- ○ Yes
- ○ No

Q28

Are your students allowed to take tablets home for educational use?

- Yes
- No

Q29

Do you use a computer at least once a week for teacher planning/preparation?

- Yes
- No

Q30

How many years have you been using the internet for teacher planning/preparation?

- Not at all
- Less than 1 year
- 1 - 2 years
- 3 - 4 years
- 5 or more years

Q31

How well do you feel prepared to use computers and internet for classroom instruction?

- Not at all prepared
- Somewhat prepared
- Well prepared
- Very well prepared

Q32

Does your school or district require technology training for teachers?

- Yes
- No

Q33

Number of hours of formal professional development in the use of computers and the internet you've participated in during the last 3 years:

- 0 hours
- 1 - 8 hours
- 9 - 32 hours
- More than 32 hours

Q34

Please list any professional development coursework you've taken related to computers and internet.

Q35

Do you have a technology/computer support person to assist you in implementing instructional technologies in your classroom curriculum?

- Yes, in my school
- Yes, in my district
- Yes, state or national meeting
- No

Page Break

Q56

The following questions centers on teacher self-efficacy. Please indicate your opinion about each of the statements below.

Q36

How much can you do to control disruptive behavior in the classroom?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q37

How much can you do to motivate students who show low interest in school work?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q38

How much can you do to get students to believe they can do well in school work?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q39

How much can you do to help your students value learning?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q40

To what extent can you craft good questions for your students?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q41 *

How much can you do to get children to follow classroom rules?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q42 *

How much can you do to calm a student who is disruptive or noisy?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q43 *

How well can you establish a classroom management system with each group of students?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q44 *

How much can you use a variety of assessment strategies?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q45 *

To what extent can you provide an alternative explanation or example when students are confused?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q46 *

How much can you assist families in helping their children do well in school?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Q47 *

How well can you implement alternative strategies in your classroom?

- Nothing
- Very Little
- Some Influence
- Quite a bit
- A great deal

Page Break

Instruction

These questions are about the effects of COVID on your students' learning achievement.

Q48

In the beginning of the COVID-19 pandemic, did you transition to online teaching?

- Yes
- No

Q49

If yes, what difficulties did you experience?
If no, write "N/A".

Q50

What challenges are you currently facing in your classroom with regards to teaching your students?
CHECK ALL THAT APPLY

- Lack of engagement
- Lack of attendance
- Lack of motivation
- COVID-19 Protocols and distancing
- Supporting different levels of student in the same course
- Lack of Discipline (Home training)
- Lack of parental support
- Other (please specify)

Q51

Please specify the content areas in mathematics you feel students need reinforcemen**CHECK ALL THAT APPLY**

- Number Properties and Operations
- Measurement
- Geometry
- Data Analysis
- Algebra
- Data Analysis, Statistics and Probability
- Algebra and Functions
- Operations and Algebraic Thinking
- Operations with Numbers
- Foundations of Counting

Q52

Please, what additional information/comments do you have that will be relevant for this research?

Q54

Thank you so much for taking the time to respond!

If you wish to be contacted in future for feedback or evaluation of the system, please continue to the end of the survey and you will be redirected to an online form to type in your email address.

If you don't wish to be contacted, please continue to the end of this survey and after you're redirected, please close that forms webpage to opt out.

Import from library | Add new question

Add Block

End of Survey

(Respondents will be redirected to https://my.forms.app/form/6266dde89df3556adb05e17e)

Please provide your email address for follow-up

1. Email address

[ ] Confirm email

Submit

Create Your Own Form   forms.app

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E. Post-Survey

Tools ∨ Saved at 9:18 AM Published Preview Publish

Post-Survey for Teachers

ExpertReview score Fair

Website Satisfaction

Q21

Please provide your feedback on the LEAP software.

Q1

What is your overall reaction to the application?

Terrible ○ ○ ○ ○ ○ Wonderful

Q2

What is your experience with the application?

Difficult ○ ○ ○ ○ ○ Easy

Q3

What describes your emotion when using the application?

Frustrating ○ ○ ○ ○ ○ Satisfying

Q4

Perceived ease of use

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
Learning to operate the system would be easy for me	○	○	○	○	○
I would find it easy to get the system to do what I want it to do	○	○	○	○	○

Q5

Ease of use

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
It is easy to use	○	○	○	○	○
It is simple to use	○	○	○	○	○
It is user friendly	○	○	○	○	○

Q6

Ease of Learning

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
I learned to use it quickly	○	○	○	○	○
It is easy to learn to use it	○	○	○	○	○

Q7

Satisfaction

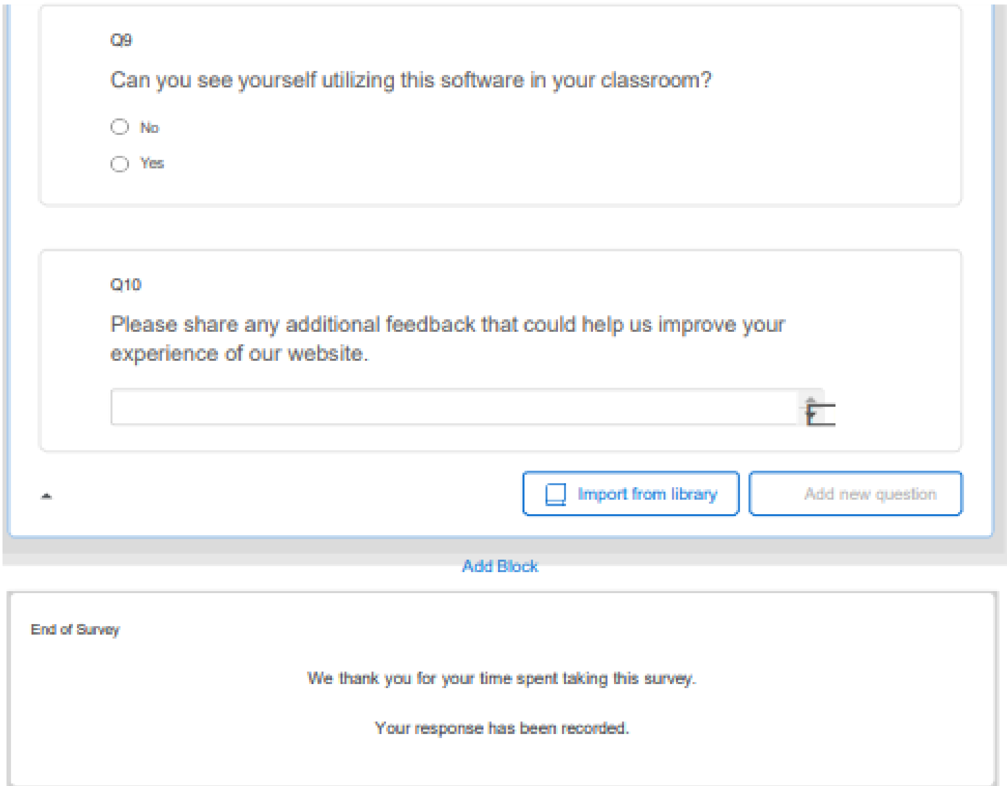
	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
I am satisfied with it	○	○	○	○	○
I would recommend it to a friend	○	○	○	○	○
It is fun to use	○	○	○	○	○
It works the way i want it to work	○	○	○	○	○
It is wonderful	○	○	○	○	○

Q8

Do you think this online portal will help students to accelerate their learning?

○ No

○ Yes


Q9

Can you see yourself utilizing this software in your classroom?

No

Yes

Q10

Please share any additional feedback that could help us improve your experience of our website.

Import from library

Add new question

Add Block

End of Survey

We thank you for your time spent taking this survey.

Your response has been recorded.

F. UX CITI Training Certificates

Completion Date 26-Jan-2022
Expiration Date 25-Jan-2025
Record ID 28482116

This is to certify that:

Onyinye Asogwa

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

IRB Additional Modules
(Curriculum Group)
Conflicts of Interest in Research Involving Human Subjects
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Auburn University

CITI
Collaborative Institutional Training Initiative

www.citiprogram.org/verify/?wa61ce2ed-c8e1-4a32-9280-1af6f609c5a1-28482116

Completion Date 27-Jan-2022
Expiration Date 26-Jan-2025
Record ID 28482117

This is to certify that:

Onyinye Asogwa

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

IRB Additional Modules
(Curriculum Group)
Defining Research with Human Subjects - SBE
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Auburn University

CITI
Collaborative Institutional Training Initiative

www.citiprogram.org/verify/?wf07640a1-299b-4796-b7e0-ba999bf9a687-28482117

CITI PROGRAM

Completion Date 27-Jan-2022
Expiration Date 26-Jan-2025
Record ID 28482113

This is to certify that:

Onyinye Asogwa

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

IRB Additional Modules
(Curriculum Group)
History and Ethical Principles - SBE
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Auburn University

CITI
Collaborative Institutional Training Initiative

www.citiprogram.org/verify/?w68efa314-179b-4aa9-8903-cb58fa20f43b-28482113

CITI PROGRAM

Completion Date 27-Jan-2022
Expiration Date 26-Jan-2025
Record ID 28482115

This is to certify that:

Onyinye Asogwa

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

IRB Additional Modules
(Curriculum Group)
Internet Research - SBE
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Auburn University

CITI
Collaborative Institutional Training Initiative

www.citiprogram.org/verify/?w868ba25b-d61f-4207-a197-e4766aec4699-28482115

CITI PROGRAM

Completion Date 31-Jan-2022
Expiration Date 30-Jan-2025
Record ID 28482112

This is to certify that:

Onyinye Asogwa

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

IRB # 2 Social and Behavioral Emphasis - AU Personnel - Basic/Refresher
(Curriculum Group)
IRB # 2 Social and Behavioral Emphasis - AU Personnel
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Auburn University

CITI
Collaborative Institutional Training Initiative

www.citiprogram.org/verify/?w3316b566-efc4-41ae-a7d9-78dc6511f67b-28482112

CITI PROGRAM

Completion Date 31-Jan-2022
Expiration Date 30-Jan-2025
Record ID 28482114

This is to certify that:

Onyinye Asogwa

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

IRB Additional Modules
(Curriculum Group)
Research in Public Elementary and Secondary Schools - SBE
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Auburn University

CITI
Collaborative Institutional Training Initiative

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Completion Date 18-Jan-2022
Expiration Date 17-Jan-2025
Record ID 42389702

This is to certify that:

Cheryl Seals

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

IRB # 2 Social and Behavioral Emphasis - AU Personnel - Basic/Refresher
(Curriculum Group)

IRB # 2 Social and Behavioral Emphasis - AU Personnel
(Course Learner Group)

1 - Basic Course
(Stage)

Under requirements set by:

Auburn University

Collaborative Institutional Training Initiative

www.citiprogram.org/verify/?w17198472-33b9-4149-9b8d-37254afd1268-42389702

CITI PROGRAM

Completion Date 23-Sep-2021
Expiration Date 22-Sep-2024
Record ID 42389704

This is to certify that:

Cheryl Seals

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

IRB Additional Modules
(Curriculum Group)
History and Ethical Principles - SBE
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Auburn University

CITI
Collaborative Institutional Training Initiative

www.citiprogram.org/verify/?wcabe5863-d5b4-4f39-a42b-5b18db20c4d4-42389704

CITI PROGRAM

Completion Date 27-Sep-2021
Expiration Date 26-Sep-2024
Record ID 42389703

This is to certify that:

Cheryl Seals

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

IRB Additional Modules
(Curriculum Group)
Conflicts of Interest in Research Involving Human Subjects
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Auburn University

CITI
Collaborative Institutional Training Initiative

www.citiprogram.org/verify/?w80c2506c-69bc-496a-9e12-9fdaf9438f1e-42389703

CITI PROGRAM

Completion Date 16-Jan-2022
Expiration Date 15-Jan-2027
Record ID 28084134

This is to certify that:

Cheryl Seals

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

Responsible Conduct of Research for Social and Behavioral
(Curriculum Group)
Social, Behavioral and Education Sciences RCR
(Course Learner Group)
2 - RCR Refresher
(Stage)

Under requirements set by:

Auburn University

CITI
Collaborative Institutional Training Initiative

www.citiprogram.org/verify/?w4491791b-7b1c-42c2-8904-14b05eb9bce3-28084134