*Athens Journal of Education 2026,12: 1-15*
https://doi.org/10.30958/aje.X-Y-Z

# Reframing College Algebra for Applied Pathways: A Context- and Technology-based Curriculum Framework

*By Xiaoyi Ji*[*]

Rapid technological advancement in applied sciences has intensified longstanding misalignments between traditional college algebra curricula and the mathematical practices required in data-driven disciplines. Drawing on instructional experience in undergraduate statistics courses at a regional public university in the United States, this paper proposes a conceptual, practice-informed framework for re-envisioning college algebra as an applied, context-driven course. The framework articulates four interconnected design principles: (1) anchoring variable identification in authentic contexts to support meaningful function and equation construction; (2) integrating both predefined and data-driven functions to promote conceptual understanding; (3) leveraging technology to support modeling, visualization, and symbolic reasoning; and (4) reprioritizing curricular content to emphasize transferable skills while streamlining legacy topics with limited applied relevance. Rather than reporting empirical outcomes, this paper offers illustrative instructional examples and design considerations intended to guide curriculum development and instructional practice in college algebra courses serving applied science pathways.

*Keywords:* College Algebra; Applied Curriculum Design; Conceptual Framework; Practice-Informed Instruction; Technology Integration; Applied Sciences.

## Introduction

Statistical education has undergone substantial transformation in recent decades, increasingly prioritizing data literacy, conceptual understanding, modeling, and real-world application. Contemporary curricula routinely incorporate authentic datasets, statistical software such as R or Python, and dynamic visualization tools, shifting instructional emphasis from manual computation toward interpretation and reasoning (Garfield & Ben-Zvi, 2008; Cobb & Moore, 1997).

College algebra, however, remains a central prerequisite for many applied science majors—including statistics, engineering, biology, economics, and computer science—yet its curriculum has changed comparatively little. As a result, students often encounter a disconnect between the symbolic procedures emphasized in college algebra and the contextualized, technology-mediated mathematical practices expected in subsequent coursework. This misalignment can hinder students' ability to transfer algebraic knowledge to applied problem-solving contexts.

This paper adopts a conceptual and practice-informed perspective, informed by repeated instructional experiences with diverse student populations at a regional public university in the United States. In particular, the framework is grounded in

---

[*] Associate Professor, Utah Valley University, USA.

instructional experiences from intermediate- and upper-division undergraduate statistics courses at Utah Valley University, which serve as a contextual lens for examining how students engage with algebraic reasoning in applied settings. These instructional contexts are not presented as empirical evidence but rather as illustrative motivation for identifying recurring curricular challenges.

Drawing on these instructional observations and supported by existing research on mathematical modeling, cognitive load, and technology-enhanced learning (Sweller, 1988; Kaput, Hegedus, & Lesh, 2007; Lesh & Doerr, 2003), this paper proposes a curriculum design framework for reframing college algebra to better support applied science pathways. The framework is organized around four interconnected principles:

1) Anchoring variable identification in authentic contexts to support meaningful function, equation, and inequality construction;
2) Integrating both predefined and data-generated models to strengthen conceptual understanding and interpretability;
3) Using technology beyond traditional calculators to integrate visualization, computation, symbolic manipulation, and reasoning; and
4) Reprioritizing content to emphasize transferable, application-relevant skills while streamlining legacy topics.

The paper references concrete instructional examples to illustrate these principles; however, its primary contribution lies not in evaluating instructional interventions but in articulating a scalable curriculum framework grounded in practice and informed by existing scholarship. As such, this work does not define a population, sample, treatment, or control group. Instead, it aims to support curriculum development and instructional decision-making and to provide a foundation for future empirical studies examining student learning outcomes in applied, technology-rich college algebra courses.

The instructional examples referenced throughout the paper are intended to illustrate recurring design challenges and opportunities in college algebra, rather than to report empirical findings; where appropriate, these examples are situated within existing research on mathematical modeling, cognitive load, and technology-supported learning.

## From Context to Symbolism: Anchoring Variable Identification in Meaningful Function and Equation Construction

Mathematics instruction traditionally progresses from concrete situations to abstract representations through logical reasoning and generalization. In principle, college algebra should reflect this progression by supporting students as they move from real-world contexts to symbolic forms such as functions, equations, and inequalities. In practice, however, constraints such as limited credit hours and heterogeneous student preparation often result in curricula that emphasize symbolic manipulation and formal notation over contextual reasoning. As a consequence, students are frequently introduced to abstract symbols (e.g., $x$, $y$, and $f(x)$) without sufficient attention to how these quantities arise from applied situations or how they represent meaningful relationships.

This section identifies variable identification and model construction as a foundational design principle for an applied college algebra curriculum. Rather than treating functions and equations as purely formal objects, an applied framework emphasizes the process of defining variables, distinguishing inputs from outputs, and constructing functional relationships grounded in contextual constraints. Instructional experiences drawn from undergraduate statistics courses at Utah Valley University (United States) are used here as illustrative contexts to motivate this design principle, not as empirical evidence of instructional effectiveness.

This emphasis aligns with prior research highlighting the central role of modeling in undergraduate mathematics and the challenges students face when transitioning from symbolic manipulation to contextual reasoning (Lesh & Doerr, 2003; Kaput, Hegedus, & Lesh, 2007). The examples that follow serve to concretize this challenge and illustrate how explicit attention to variable identification can support deeper conceptual understanding.

In a traditional college algebra course, the chapter on functions typically includes objectives such as defining a function, determining domains and ranges, graphing functions, performing operations on functions, and introducing inverse and one-to-one functions. While these topics support procedural fluency, they often underemphasize the initial modeling step—identifying relevant variables and expressing their relationships mathematically. This gap becomes especially visible when students encounter applied problems in statistics and other data-driven disciplines, where translating contextual information into mathematical form is essential.

Illustrative Example 1: Call Center Modeling

Consider the following problem, drawn from a Statistics for Engineering course with 24 students enrolled:

Illustrative Example 1 (Original Version).
*At a call center, the number of incoming calls per minute follows a Poisson distribution with a mean of 3. Due to staffing limitations, the center can handle at most 5 calls per minute; any additional calls beyond the first 5 are not answered. Find and interpret the expected number of calls answered per minute.*

Although students were familiar with the formula for expected value, nearly all expressed uncertainty about how to proceed, questioning whether information was missing from the problem. Importantly, this difficulty did not arise from probability theory or computational technique but from the absence of explicitly defined variables and relationships. To support students' reasoning, the problem was revised to make the variables explicit:

Illustrative Example 1 by adding (Revised Version).
*Let* $T$ *represent the total number of calls arriving in a minute, and let* $A$ *denote the number of calls actually answered. Find and interpret the expected number of calls answered per minute.*

With variables clearly defined, students were able to articulate that the objective was to compute $E(A)$. They identified two conceptual approaches:

$$E(A) = \sum a_i P(A = a_i) \qquad (1)$$

or

$$E(A) = \sum A(t_i) P(T = t_i). \qquad (2)$$

Because the probability distribution of $T$was known, students selected the second approach (2), which required defining the function $A(T)$. At this stage, the instructional focus shifted from computation to function construction, a competency that is often underdeveloped in college algebra despite extensive symbolic exposure.

To make this modeling step explicit, the problem was further structured to emphasize a systematic process:

- Identify and define the variables, distinguishing independent and dependent quantities;
- Formulate the relationship between variables as a function based on contextual constraints;
- Identify the probability distribution of the independent variable;
- Compute and interpret the expected value.

Despite these supports, many students struggled to express the relationship as a piecewise-defined function,

$$A(T) = \begin{cases} T, & 0 \leq T \leq 5, \\ 5, & T > 5. \end{cases} \qquad (3)$$

and some were uncertain about how to interpret or apply the function's branches when substituting (3) into $E(A) = \sum A(t_i) P(T = t_i)$. Many students struggle with these concepts in college algebra or precalculus because they're often presented abstractly—through symbolic definitions, graphs without labels, or exercises focused on computation rather than interpretation. Without real-world context, the independent variable feels arbitrary, and the function's "steps" can seem like disconnected rules rather than a unified model. These difficulties surfaced even among students enrolled in calculus-based, upper-division statistics courses, suggesting that prior symbolic instruction alone does not ensure conceptual understanding of functions in applied contexts. This observation is consistent with research on cognitive load and students' difficulty coordinating multiple representations when symbolic procedures are emphasized without contextual grounding (Sweller, 1988; Hiebert & Grouws, 2007).

### Illustrative Exam Context: Printer Lifetime Modeling

A similar pattern emerged in an upper-division mathematical statistics course through the following exam question:

Illustrative Exam Context.

*The lifetime* $T$ *of a printer follows an exponential distribution with a mean of two years. A company replaces each printer either when it fails or after five years, whichever comes first. Let* $U$ *denote the actual usage time. Find and interpret* $E(U)$*, the expected usage time.*

Only a small number of students successfully defined $U(T)$ before attempting computation. Once again, the primary obstacle was not the calculation of an expected value but the formulation of the underlying functional relationship. This recurring difficulty reinforces the observation that students' challenges often arise at the modeling stage, rather than in subsequent algebraic or statistical procedures.

These examples are not presented as outcome measures or comparative evidence. Instead, they function as practice-informed illustrations that motivate a core design principle: an applied college algebra curriculum should explicitly foreground variable identification and functional modeling as foundational skills. By systematically embedding these processes within authentic contexts, college algebra can better prepare students to engage meaningfully with applied mathematics in statistics and related disciplines.

## From Abstract Formulas to Interpretable Models: Leveraging Context and Data to Support Conceptual Understanding

Traditional college algebra instruction often introduces relationships between variables through abstract symbols and predefined algebraic forms—such as functions, equations, and inequalities—with limited reference to how these forms arise from real situations. While this approach supports procedural fluency and symbolic manipulation, it can obscure the meaning of variables and parameters, particularly for students in applied and data-oriented disciplines. As research on mathematical modeling and representational understanding suggests, students frequently struggle to attach meaning to algebraic symbols when instruction emphasizes form over context (Hiebert & Grouws, 2007; Lesh & Doerr, 2003).

This section uses instructional examples drawn from undergraduate statistics courses to illustrate how contextualized and data-driven functions can support deeper conceptual understanding in college algebra. These examples are presented as design exemplars, not as outcome measures, and are intended to motivate curricular principles rather than to evaluate instructional effectiveness.

### Contextualizing Predefined Functions: Interpreting Slope Beyond Symbols

As an illustrative starting point, consider the linear function

$$y = 15x + 50. \qquad (4)$$

In many college algebra texts, this equation is introduced abstractly, with instruction focusing on identifying the slope as the coefficient of $x$ and the intercept as the value of $y$ when $x = 0$. While procedurally correct, such treatment often fails to emphasize interpretation. In contrast, when the same equation is situated in context—where $y$represents total earnings (in dollars) and $x$represents hours worked—the slope acquires a concrete meaning as a rate of change measured in dollars per hour.

In instructional settings, students were asked to interpret the slope of equation 4 in both an abstract form and a contextualized earnings scenario. These questions were used diagnostically to examine patterns of student reasoning, not to conduct a controlled comparison or to measure learning gains.

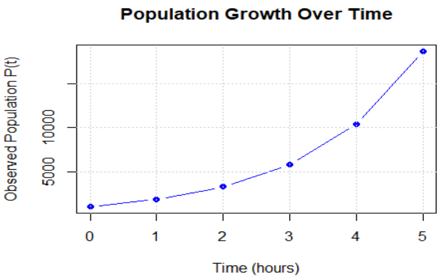
Across multiple offerings of intermediate statistics courses, instructors observed that student responses were more coherent and internally consistent when the slope was interpreted within a real-world context. Reported ranges such as 5%–87% for abstract interpretations and 62%–92% for contextualized interpretations reflect variation across different course sections and semesters. These figures are included solely to illustrate the magnitude and variability of observed reasoning patterns, not to claim statistically validated improvement or causal effects.

The key design insight is therefore not that contextualization "raises scores," but that it stabilizes the meaning of slope by anchoring it to identifiable quantities with units. This observation aligns with prior work on rate of change and covariational reasoning, which emphasizes the importance of context in supporting students' conceptualization of slope (Thompson, 1994; Carlson et al., 2002). For an applied college algebra curriculum, this suggests that contextual interpretation should be treated as central rather than supplementary when introducing predefined functional forms.

## Integrating Data-Driven Functions: From Observation to Model Construction

Beyond predefined formulas, applied disciplines frequently rely on models constructed directly from observed data. To illustrate how data-driven modeling can be incorporated into a college algebra course, consider the following instructional example adapted from biological growth modeling.

**Figure 1.**



Suppose a biologist observes the growth of a bacterial population beginning with an initial population of 1,000 cells. Measurements collected over time, shown in the scatter plot in Figure 1, suggest accelerating growth, motivating consideration of an exponential model of the form of equation (5)

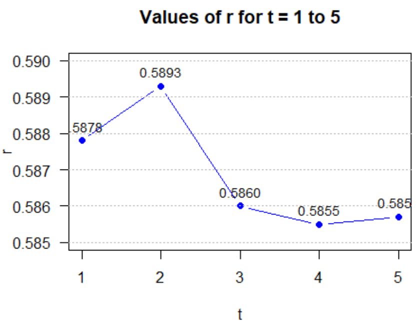
$$P(t) = P_0 e^{rt}. \qquad (5)$$

To estimate the growth rate r from the observed data, an estimate is computed for each data point (excluding (t = 0)) using

$$r_t = \frac{1}{t} ln\left(\frac{P(t)}{1000}\right). \qquad (6)$$

The resulting estimates of r for five different time points (t = 1 to 5) are plotted in Figure 2 to support discussion of an appropriate estimation strategy.

**Figure 2.**



Several options can be posted for students' consideration:

- With only five data points and very small variation in the estimated values of r (ranging from approximately 0.5855 to 0.5893), the growth rate appears essentially stable over this short time period, with no strong trend.
- If a trend over time—even a mild one—is suspected, a linear or quadratic model for r as a function of t could be explored.
- With additional data collected over a longer time span, students could more effectively assess whether such a trend exists.
- Given the current data, simplicity is reasonable: treating r as approximately constant and using the average value, r, is an appropriate modeling choice. Based on this reasoning, one reasonable model consistent with the observations is
- $$P(t) = 1000e^{0.5868t}. \qquad (7)$$

The equation (7) is presented as a constructed instructional example intended to illustrate the modeling process rather than to report student-generated models or learning outcomes. The pedagogical value lies in the sequence of reasoning: defining variables, visualizing data, selecting a functional form, estimating parameters, and interpreting the resulting model.

Introducing this process in college algebra allows students to see functions not merely as given formulas but as tools created to describe real phenomena. This perspective aligns with research emphasizing modeling as a core mathematical practice and highlighting the role of data in supporting conceptual understanding (Lesh & Doerr, 2003; National Research Council, 2012).

Importantly, this example is not used to assess student understanding or performance. Instead, it demonstrates how college algebra can integrate both predefined and data-driven functions in ways that align with the mathematical demands of statistics, biology, engineering, and other applied sciences.

### Design Implications for an Applied College Algebra Framework

Taken together, these illustrative examples support a core principle of the proposed curriculum framework: conceptual understanding is strengthened when algebraic functions are consistently connected to meaningful contexts and data. By combining contextualized interpretation of predefined functions (such as linear models) with opportunities to construct data-driven models (such as exponential growth), college algebra can better prepare students for applied, technology-rich disciplines.

This section does not present an empirical study with defined populations, treatments, or control groups. Rather, it offers practice-informed design exemplars that motivate curricular realignment and inform the development of an applied college algebra framework. These exemplars are intended to guide instructional design and to serve as a foundation for future empirical investigations into student learning outcomes.

## Technology as Cognitive Support:
## Integrating Modeling, Visualization, and Symbolic Manipulation

The modeling challenges illustrated in the previous sections—such as identifying variables, constructing functional relationships, and interpreting parameters—highlight a broader instructional issue: traditional algebraic tools often place excessive cognitive demands on students at precisely the stages where conceptual understanding is still developing. Technology, when used deliberately, can help redistribute this cognitive load by automating routine computation and visualization, allowing students to focus on meaning-making and model construction rather than procedural execution.

This section situates technology as an integral component of an applied college algebra framework. The goal is not to replace algebraic reasoning, nor to claim instructional effectiveness through experimental comparison, but to illustrate how digital tools can support modeling, visualization, and symbolic manipulation in ways that align with the demands of applied sciences. This framing is consistent with research emphasizing the role of technology in supporting representational fluency and conceptual understanding in mathematics education (Kaput, 1992; Tall, 1991; National Council of Teachers of Mathematics [NCTM], 2018).

## Visualization and Functional Exploration Beyond Hand Graphing

In traditional college algebra instruction, students often graph functions by computing a small number of ordered pairs using calculators and plotting them manually on paper. While this approach reinforces arithmetic skills, it produces static representations and limits students' ability to explore how changes in input affect output across a function's domain. Research on multiple representations suggests that such limitations can hinder students' development of covariational reasoning and functional understanding (Carlson et al., 2002; Duval, 2006).

Digital tools such as Excel or R enable students to input functions directly in Figure 1 based on observed data, generate dense sets of ordered pairs, and produce dynamic graphs instantaneously. By adjusting input values systematically, students can observe how changes in $x$ influence $y$, supporting a deeper understanding of domain, range, monotonicity, and rate of change. Within the proposed framework, these tools are not presented as instructional interventions but as design supports that make functional relationships more visible and interpretable.

Importantly, this form of visualization aligns with earlier modeling examples in this paper. Once variables and functional forms have been defined, technology allows students to explore those relationships interactively, reinforcing the connection between symbolic expressions and their graphical meanings.

## Technology-Supported Modeling and Parameter Estimation

Technology also plays a critical role in extending college algebra beyond predefined functions toward data-driven modeling. As discussed in Section 3, applied disciplines frequently construct models from observed data rather than relying solely on closed-form formulas. Tools such as Excel or R allow students to input datasets, visualize trends, and estimate model parameters—such as slopes and intercepts for linear models or coefficients for quadratic and exponential models—using built-in regression and fitting functions. In the example in *Integrating Data-Driven Functions: From Observation to Model Construction*, the precisely visualized plot generated using Excel in Figure 1, rather than a hand-sketched diagram, allowed students to more accurately select an exponential function to model the relationship between t and P. Similarly, displaying the relationship between $t$ and $r$ in Figure 2 with a scatter plot by using R enabled students to estimate $r$ using the average of the computed values of $r_i$, given the limited values of $r_i, i = 1,2,...,5$, and the absence of a clear pattern in $r$ over time.

Another example, while traditional exercises often ask students to find the equation of a line given exactly two points, technology enables exploration of situations involving multiple data points, where the "best-fit" model must be estimated rather than uniquely determined. This shift mirrors authentic practices in statistics, engineering, and science, where models are evaluated based on fit and interpretability rather than algebraic exactness (Lesh & Doerr, 2003; National Research Council, 2012).

Within the proposed framework, these modeling activities are used to illustrate curricular possibilities, not to assess student performance. Their purpose is to demonstrate how technology can support the modeling cycle—data visualization, model selection, parameter estimation, and interpretation—within a college algebra course.

## Supporting Symbolic Reasoning Through Computational Tools

Beyond functions and modeling, technology can also support symbolic reasoning by reducing the procedural burden of algebraic manipulation. For instance, solving systems of equations using manual row operations is time-consuming and prone to error, particularly for students with weaker algebraic backgrounds. Research on cognitive load theory suggests that excessive procedural demands can interfere with conceptual understanding (Sweller, 1988; Sweller et al., 2011).

Computational environments such as R allow students to perform elementary row operations programmatically, making each transformation explicit while minimizing arithmetic errors. For example, the following R script demonstrates the solution of a linear system using elementary row operations:

Traditional methods, such as manually performing elementary row operations, are time-consuming and prone to errors. To minimize mistakes, students often need to rewrite the updated matrix after each step to determine the appropriate next operation. In contrast, R allows students to perform each row operation easily using basic arithmetic, and they can use simple commands like print() to display the matrix after each step, significantly improving clarity and efficiency. The same approach applies when using Gauss–Jordan elimination to find the inverse of a matrix in R. The following R script demonstrates how to solve a system of equations using elementary row operations:

```
# R Script to Solve a System of Equations via Elementary Row
Operations

# The system:
# 2x + 3y = 8
# 4x - y  = 2
# Augmented matrix: [2  3 | 8; 4 -1 | 2]

# Step 0: Create the augmented matrix
A <- matrix(c(2, 3, 8,
              4, -1, 2),
            nrow = 2, byrow = TRUE)
cat("Original Augmented Matrix:\n")
## Original Augmented Matrix:
## Original Augmented Matrix:
print(A)
##      [,1] [,2] [,3]
## [1,]    2    3    8
## [2,]    4   -1    2
# Step 1: Divide the first row by 2 to get a leading 1 in the
first row.
```

```
A[1, ] <- A[1, ] / 2
cat("After dividing row 1 by 2:\n")
## After dividing row 1 by 2:
print(A)
##      [,1] [,2] [,3]
## [1,]    1  1.5    4
## [2,]    4 -1.0    2
# Row 1 becomes: [1, 1.5, 4]

# Step 2: Eliminate the x-term in row 2.
# Replace row 2 with row 2 - 4 * row 1.
A[2, ] <- A[2, ] - 4 * A[1, ]
cat("After eliminating x from row 2 (Row2 - 4*Row1):\n")
## After eliminating x from row 2 (Row2 - 4*Row1):
print(A)
##      [,1] [,2] [,3]
## [1,]    1  1.5    4
## [2,]    0 -7.0  -14
# Row 2 becomes: [0, -7, -14]

# Step 3: Divide row 2 by -7 to obtain a leading 1.
A[2, ] <- A[2, ] / (-7)
cat("After dividing row 2 by -7:\n")
## After dividing row 2 by -7:
print(A)
##      [,1] [,2] [,3]
## [1,]    1  1.5    4
## [2,]    0  1.0    2
# Row 2 becomes: [0, 1, 2]

# Step 4: Eliminate the y-term in row 1.
# Replace row 1 with row 1 - 1.5 * row 2.
A[1, ] <- A[1, ] - 1.5 * A[2, ]
cat("Final Reduced Row-Echelon Form:\n")
## Final Reduced Row-Echelon Form:
print(A)
##      [,1] [,2] [,3]
## [1,]    1    0    1
## [2,]    0    1    2
# Row 1 becomes: [1, 0, 1]; Row 2 becomes: [0, 1, 2]

# This implies that x = 1 and y = 2.
```

These tools make symbolic transformations transparent while reducing procedural burden. Students can focus on *why* each operation is performed and *how* it transforms the system, supporting a deeper understanding of equivalence and solution structure. This approach aligns with research emphasizing the importance of linking symbolic manipulation to conceptual meaning (Tall & Vinner, 1981; Hiebert & Grouws, 2007).

### Design Implications for Technology Use in Applied College Algebra

Taken together, these examples position technology as a conceptual amplifier within an applied college algebra framework. Visualization tools support functional reasoning, modeling tools connect data to mathematical structure, and computational environments reduce unnecessary procedural load while preserving symbolic meaning.

This section does not evaluate the effectiveness of specific technologies, nor does it compare technology-enhanced instruction with traditional methods. Instead, it articulates design principles for integrating technology in ways that align college algebra with applied, data-driven disciplines. These principles are intended to guide curriculum design and instructional decision-making and to provide a foundation for future empirical research examining how technology-supported algebra instruction influences student learning.

## Reprioritizing Content for Applied Relevance: Streamlining Legacy Topics and Emphasizing Transferable Skills

A central challenge in redesigning college algebra for applied sciences is not merely what to add to the curriculum, but what to de-emphasize or remove. Given limited instructional time and increasingly diverse student backgrounds, curriculum design necessarily involves prioritization. This section argues that college algebra should emphasize transferable mathematical skills that support modeling, interpretation, and technological fluency, while streamlining legacy topics whose instructional costs outweigh their applied relevance.

This position aligns with broader calls in mathematics education to rethink traditional content sequences in light of contemporary disciplinary needs and technological capabilities (National Research Council, 2012; NCTM, 2018). The discussion that follows does not evaluate student outcomes or compare alternative curricula. Instead, it articulates design considerations intended to guide curriculum decision-making in applied college algebra.

### Re-evaluating Traditional Emphases in Algebra Instruction

Many college algebra syllabi devote substantial time to manual algebraic techniques such as polynomial long division, synthetic division, hand graphing of higher-degree polynomials, and solving for exact zeros—including complex roots—using symbolic methods. Historically, these topics played an important role in preparing students for advanced theoretical mathematics. However, for students pursuing applied fields such as statistics, engineering, biology, economics, or computer science, these techniques are rarely used in isolation or performed by hand.

In contemporary applied practice, polynomial models are typically analyzed using computational tools that approximate roots, generate graphs, and assess model behavior numerically. While understanding the *existence* and *interpretation* of roots remains conceptually important, mastery of manual solution techniques is no longer central to applied problem-solving. Research on cognitive load suggests that extensive emphasis on such procedures can divert attention from higher-level reasoning and interpretation (Sweller, 1988; Sweller et al., 2011).

Within an applied college algebra framework, the goal is not to eliminate theoretical content entirely, but to reconsider the depth and instructional time allocated to procedures that have limited transfer beyond the algebra classroom.

## Emphasizing Transferable Concepts and Representational Fluency

In contrast, several algebraic ideas offer high transfer value across applied disciplines and warrant increased emphasis. These include:

- Understanding rates of change and functional behavior
- Interpreting parameters in context
- Using logarithmic transformations to linearize relationships
- Reasoning across multiple representations (symbolic, graphical, numerical, and verbal)

For example, logarithmic functions play a central role in data analysis, finance, engineering, and the natural sciences. Beyond algebraic manipulation, logarithms support model interpretation, scale transformation, and the identification of exponential trends in empirical data. Emphasizing these applications aligns college algebra more closely with the modeling practices students encounter in statistics and science courses (Duval, 2006; Lesh & Doerr, 2003).

Similarly, facility with interpreting functional forms—rather than deriving them symbolically—supports students' ability to transfer algebraic knowledge to new contexts. Research on conceptual understanding highlights the importance of connecting formal definitions with intuitive meaning and real-world interpretation (Tall & Vinner, 1981; Hiebert & Grouws, 2007).

## Technology as a Catalyst for Content Reprioritization

Technology plays a critical role in enabling content reprioritization. When computational tools handle routine algebraic manipulation, instructional time can be reallocated toward interpretation, modeling, and decision-making. For instance, rather than teaching polynomial division as a manual skill, instructors can use software to explore how polynomial models behave, how roots affect graphs, and how approximations inform applied decisions.

This shift reflects a broader movement in mathematics education toward using technology to support sense-making rather than procedural rehearsal (Kaput et al., 2007; Pierce & Stacey, 2010). Within the proposed framework, technology is not treated as an add-on but as a structural component that allows college algebra to focus on concepts with enduring relevance.

### Design Implications for an Applied College Algebra Framework

Taken together, these considerations support a key design principle of the proposed framework: college algebra should prioritize content that promotes conceptual understanding, modeling competence, and transfer to applied contexts. Streamlining legacy topics is not a reduction of rigor, but a redefinition of rigor in terms of relevance, interpretability, and applicability.

This section does not propose a fixed list of topics to remove or retain, nor does it claim empirical validation of specific content choices. Instead, it offers a conceptual lens for evaluating curriculum priorities in light of applied disciplinary needs and technological realities. These design principles are intended to inform curriculum development and to serve as a foundation for future empirical research examining how content reprioritization influences student learning and transfer.

## Conclusion

As applied sciences continue to evolve in response to technological and data-driven demands, the role of college algebra as a foundational course requires careful reconsideration. This paper has argued that longstanding misalignments between traditional college algebra curricula and applied disciplinary needs stem not from a lack of mathematical rigor, but from an instructional focus that prioritizes symbolic form over contextual meaning, procedural fluency over modeling competence, and legacy content over transferable skills.

From a conceptual and practice-informed perspective, the paper proposed a curriculum design framework for an applied college algebra course organized around four interconnected principles.

The examples presented throughout the paper are intentionally illustrative rather than evaluative. They are drawn from instructional contexts in undergraduate statistics courses and are used to motivate design principles, not to claim measured learning outcomes or instructional effectiveness. Accordingly, this work does not define a study population, treatment, or control group, nor does it report empirical results. Its contribution lies in articulating a scalable and actionable framework that can guide curriculum redesign, inform instructional decision-making, and support alignment between college algebra and applied, technology-rich disciplines.

By reframing college algebra as a modeling-oriented, context-driven course, this framework aims to better prepare students for statistics and other applied sciences while preserving the conceptual foundations of algebra. Future research can build on this framework by empirically examining how these design principles influence student understanding, transfer, and persistence across diverse institutional contexts.

# References

Boyce, S., & O'Halloran, J. (2019). *Active Learning in Computer-based College Algebra*. PRIMUS, 1–17.

Carlson, M. P., Jacobs, S., Coe, E., Larsen, S., & Hsu, E. (2002). Applying covariational reasoning while modeling dynamic events: A framework and a study. *Journal for Research in Mathematics Education, 33*(5), 352–378. https://doi.org/10.2307/4149958

Cobb, G. W., & Moore, D. S. (1997). Mathematics, statistics, and teaching. *The American Mathematical Monthly, 104*(9), 801–823. https://doi.org/10.2307/2975286

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics, 61*(1–2), 103–131. https://doi.org/10.1007/s10649-006-0400-z

Garfield, J., & Ben-Zvi, D. (2008). *Developing students' statistical reasoning: Connecting research and teaching practice*. Springer.

Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 371–404). Information Age.

Kaput, J. J. (1992). Technology and mathematics education. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 515–556). Macmillan.

Kaput, J. J., Hegedus, S., & Lesh, R. (2007). Technology becoming infrastructural in mathematics education. In R. Lesh et al. (Eds.), *Foundations for the future in mathematics education* (pp. 173–192). Lawrence Erlbaum.

Lesh, R., & Doerr, H. M. (2003). *Beyond constructivism: Models and modeling perspectives on mathematics problem solving, learning, and teaching*. Lawrence Erlbaum.

National Council of Teachers of Mathematics. (2018). *Catalyzing change in high school mathematics: Initiating critical conversations*. NCTM.

National Research Council. (2012). *Education for life and work: Developing transferable knowledge and skills in the 21st century*. National Academies Press.

Pierce, R., & Stacey, K. (2010). Mapping pedagogical opportunities provided by mathematics analysis software. *International Journal of Computers for Mathematical Learning, 15*(1), 1–20.

Porter, Rhonda C.; Ofoldile, Chinenye; and Carthon, Janis (2015) "Redesigning College Algebra for Success: An Analysis of Student Performance," *Georgia Journal of Science*, Vol. 73, No. 2, Article 5. Available at: https://digitalcommons.gaacademy.org/gjs/vol73/iss2/5

Ragsdale, T. L., Akin, R., & Warren, G. (2021). Co-requisite Redesign Leads to Increased College Algebra Success and College Completion. Journal of Access, Retention, and Inclusion in Higher Education, 4(1). Retrieved from

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(2), 257–285.

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. Springer.

Tall, D. (1991). The psychology of advanced mathematical thinking. In D. Tall (Ed.), *Advanced mathematical thinking* (pp. 3–21). Kluwer.

Tall, D., & Vinner, S. (1981). Concept image and concept definition in mathematics. *Educational Studies in Mathematics, 12*(2), 151–169.

Thompson, P. W. (1994). Students, functions, and the undergraduate curriculum. In E. Dubinsky et al. (Eds.), *Research in collegiate mathematics education I* (pp. 21–44). AMS.