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Engineering Pathways in Education and The Credit Loss Challenge

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Introduction

Overview

Students entering higher education programs with the intent to transfer will encounter terms like "credit" and "transfer" often with only a vague understanding of their significance. For many, "credit" seems like a straightforward transaction: an acknowledgment of effort invested in mastering essential concepts. In this transactional view, the credit earned is universally valuable and transferable, much like currency in an open market. However, the reality is far more complex, particularly for engineering students.

Since approximately 42% of engineering graduates attended community college at some point in their academic journey (Schott & Orndoff, 2019), the community college transfer student is an important part of the engineering education workforce pipeline, highlighting the critical need to address the credit loss challenges faced by transfer students withing engineering transfer pathways. This study examines engineering transfer pathways in Indiana, Texas, and Washington to identify best practices in credit loss prevention through course sequence protections, transfer support, and minimization of course redundancy that could enhance California's Associate Degree for Transfer (ADT) framework for engineering students. Through examination of these established programs, this research provides insights into how structured transfer pathways can address the unique challenges of engineering curricula while supporting student success.

Background Information

For engineering transfer students, understanding how credit transfer works is crucial to achieving their educational goals. The credits engineering students earn belong to highly sequential curricula, which means students must cautiously navigate to avoid missed or split sequences to avoid a delay in graduation. This phenomenon is often referred to as the "cascading effect" (Reeping et al., 2020). These delays occur when credits earned at one institution fail to transfer or apply to a degree program at another, resulting in credit loss that not only extends time to graduation but also decreases a student's likelihood of graduating altogether (Monaghan & Attewell, 2015)

Community colleges serve as an entry point for diverse and non-traditional transfer students, including first-generation students, single parents, foster youth, returning industry professionals, and historically underrepresented populations (Smith et al., 2021; Lakin & Cardenas Elliott, 2016), amplifying the effect of credit loss. Students from community colleges often rely on critical support services, yet face unique challenges navigating the transfer process, compounded by misconceptions about how credits transfer.

To balance competing obligations, students may attend multiple institutions, selecting courses perceived to transfer, resulting in credits earned which do not transfer. While these strategies provide short-term solutions to conflicting schedules, program requirements, or obligations, students may encounter credit loss due to unclear institutional policies or misaligned credit articulation processes when courses are taken that unknowingly do not align with their transfer goals. University websites are a key resource for transfer students, Reeping and Knight (2021) note that fragmented, inaccessible, and contradictory information exacerbates knowledge gaps.

These combined challenges amplify systemic inequities, disrupt educational progress, and extend time to graduation.

Purpose of the Research

To examine the effectiveness of Associate Degree for Transfer (ADT) frameworks in mitigating credit loss, streamlining transfer processes, and increasing graduation rates for engineering transfer students in California, this study analyzes successful ADT implementations in Florida, Washington, and Indiana. The research evaluates key elements of engineering transfer pathways, including prerequisite courses, major requirements, general education credits, transfer timing, course sequencing, and credit evaluation processes. These states were chosen for their established ADT programs, offering insights into clear articulation agreements, course equivalency strategies, and targeted support systems. Focusing on five high-enrollment engineering disciplines, Mechanical, Civil, Electrical, Chemical, and Aerospace Engineering, this study provides actionable recommendations to address the unique challenges of engineering curricula and enhance transfer pathways for California's students.

Objectives

By analyzing the best practices from these models, the research provides insights into enhancing California's existing ADT framework with best practices for engineering pathways.

- **Analyze and Compare ADT Frameworks Across Selected States**

  Examine the structure, policies, and outcomes of ADT programs in Florida, Washington, and Indiana, with a focus on engineering disciplines.

- **Identify Successful Practices in Engineering Transfer Pathways**

  Highlight best practices in articulation agreements, course equivalency processes, and student support systems that effectively reduce credit loss and time to graduation.

- **Evaluate Applicability to California's Context**

  Assess the relevance of identified best practices to California's unique challenges in engineering transfer pathways, including the state's existing ADT framework.

- **Develop Recommendations for California's ADT Framework**

  Identify methods of credit loss reduction, optimization for transfer processes, and enhanced support systems, creating a guide for engineering pathways within California's ADT framework.

Literature Review

Credit loss is a critical barrier to degree completion for engineering transfer students, stemming largely from a fundamental misalignment between how students understand credit transfer and how institutions implement transfer policies. This misalignment is especially problematic in engineering, where sequential curricula create complex dependencies that students must navigate successfully to avoid delays in degree completion.

Causes of Credit Loss in Engineering Transfer Pathways

Credit loss occurs when courses completed at a sending institution fail to transfer or apply to degree requirements at a receiving institution. This inefficiency results in extended time to degree, increased costs, and heightened barriers to graduation. Key contributors include: highly sequential curricula in engineering programs, and misaligned student perceptions with institutional policy. Missing a prerequisite course can delay graduation by multiple semesters (Smith et al., 2021; Johnson & Smith, 2022). Giani et al. (2024) highlight that the likelihood of credit loss varies significantly across course characteristics and majors, emphasizing the need for tailored approaches to mitigate these losses.

Fragmented Information and Policies

Students face fragmented and often contradictory information regarding transfer pathways. Reeping and Knight (2021) identified "information asymmetries" as a major contributor to student confusion, where institutional websites fail to provide accessible and cohesive transfer guidelines (Reeping & Knight, 2021; Johnson & Smith, 2022). The study by Wetzel and Debure (2018) tells us that transfer students encounter significant challenges due to poorly organized web-based information, further complicating their understanding of transfer processes.

Variability in Articulation Agreements

While some states, such as Florida, have standardized course numbering systems to improve credit transfer, inconsistencies persist across states and institutions. These differences leave students vulnerable to losing credits when transferring between institutions without robust articulation agreements (Johnson & Smith, 2022; Baker, 2016). Giani et al. (2024) emphasize the need for comprehensive frameworks to guide credit loss research and reforms, particularly in understanding how articulation agreements can be optimized. Institutional Policies and Advising Institutional policies often lack coordination between sending and receiving institutions. This misalignment can result in courses that transfer but do not apply toward degree requirements. Advisors, while critical, are often underprepared to navigate these complexities, further compounding the issue (Baker, 2016; Lee et al., 2023). The findings from Wetzel and Debure (2018) suggest that faculty and advisors must pay close attention to the unique needs of transfer students to facilitate their academic success.

Transfer Shock and Adjustment Barriers

Transfer students frequently experience "transfer shock," characterized by a decline in GPA during the initial post-transfer terms. Smith et al. (2021) found that this phenomenon can extend beyond the first term and disproportionately affects underrepresented groups, highlighting the need for targeted support during the transition (Smith et al., 2021; Lee et al., 2023). The study by Smith and Van Aken (2020) indicates that transfer shock can significantly impact graduation rates, underscoring the importance of understanding this phenomenon in the context of engineering transfer students.

While the structural causes of credit loss are important, understanding how students perceive and navigate these systems is crucial for addressing the problem. Student perceptions of credit transfer often differ significantly from institutional realities, creating a gap that leads to unintended credit loss.

The Role of Student Perception in Credit Loss

Student perceptions of the transfer process significantly shape their outcomes. Many students operate under the assumption that all credits earned will seamlessly apply to their degree, a misconception that is particularly detrimental in highly structured programs like engineering. Berhane et al. (2024) revealed that marginalized groups, including Black engineering students, often navigate heavily racialized systems while encountering unclear policies and limited resources, further compounding credit loss (Berhane et al., 2024). Lee et al. (2023) proposed that localized structural features and power dynamics within institutions can unjustly shape the demands and opportunities students face, influencing their decision-making and academic trajectories.

Investigating ADT as a Framework for Perception Alignment

Through examining the misalignment between student perceptions and institutional policies, the Associate Degree for Transfer (ADT) framework emerged as a potentially significant but understudied approach to bridging this gap. While ADTs exist in several states, their effectiveness in aligning student understanding with engineering transfer requirements remains largely unexamined. ADTs standardize prerequisites, course equivalencies, and transfer eligibility criteria, offering a clearer pathway from community colleges to four-year institutions. States like California and Florida have implemented ADTs with some success, providing a foundation for further investigation into their effectiveness in aligning student perceptions with institutional policies (Johnson & Smith, 2022; Berhane et al., 2024). ADT frameworks could be particularly relevant for addressing credit loss in engineering pathways. By clearly defining which courses meet degree requirements, ADTs reduce uncertainty and help students make informed decisions. Research by Baker (2016) found that departments offering ADTs experienced a 35% increase in degrees granted, highlighting the potential of structured pathways to enhance completion rates (Baker, 2016). Additionally, Giani et al. (2024) suggest that understanding the interaction of various factors influencing credit loss can help refine ADT frameworks to better serve transfer students. However, while ADTs show promise, their implementation varies across institutions and disciplines, and there are concerns about equity. High-achieving subgroups may disproportionately benefit, potentially exacerbating existing disparities (Baker, 2016). Further research is needed to evaluate their effectiveness in different contexts, particularly for engineering transfer students (Lee et al., 2023; Johnson & Smith, 2022).

Research Gaps and Future Directions

While the causes of credit loss are well-documented, significant gaps remain in the literature: Lack of Multi-State and Multi-Institution Studies. Most research focuses on single states or institutions, limiting the generalizability of findings. Comparative analyses of ADT frameworks across diverse educational systems could provide valuable insights into their broader applicability (Johnson & Smith, 2022; Baker, 2016). Few studies examine how students interpret and navigate transfer pathways. Understanding these perceptions is critical for developing interventions that address misconceptions and improve outcomes (Baker, 2016; Berhane et al., 2024). A critical gap exists in understanding how engineering transfer students develop their perceptions of credit transfer and why these perceptions often misalign with institutional policies. While ADT frameworks show promise for addressing this misalignment, their effectiveness in engineering contexts requires systematic investigation.

Engineering-Specific Challenges

Engineering pathways pose unique challenges due to their sequential nature. Further research should explore how frameworks like ADTs can be adapted to meet the specific needs of engineering transfer students (Baker, 2016; Lee et al., 2023). Institutional Factors and Ecosystem Approaches Ecosystem models that account for structural dynamics, power relations, and student agency provide a promising lens for analyzing transfer challenges. Such models can reveal hidden barriers and identify opportunities for systemic reform (Berhane et al., 2024; Lee et al., 2023). Equity Considerations in Structured Pathways Baker (2016) highlighted concerns that ADTs might unintentionally favor high-performing students, while vulnerable groups face barriers such as course capacity constraints. Addressing these equity challenges should be a priority in future research (Baker, 2016; Johnson & Smith, 2022).

Methodology

Research Design Evolution and Perspective

This study employs a multistate analysis examining how Associate Degrees for Transfer (ADT) frameworks in engineering programs address credit loss and transfer pathway challenges to identify potential best practices in California. This study focuses on Indiana's Transfer Single Articulation Pathway (TSAP) which emphasizes competency-based learning outcomes with guaranteed junior status, Texas's foundational engineering framework, which focuses on credit applicability through statewide guaranteed transfer agreements, and Washington's AS-T Track 2 framework which incorporates transfer protection mechanisms and sequence preservation. The analysis focuses on five high-enrollment engineering disciplines (Mechanical, Civil, Electrical, Chemical, and Aerospace Engineering), selected for their widespread availability and sequential curricula which pose documented challenges for credit transfer and institutional alignment.

The research design was informed in part by the researcher's experience as an engineering transfer student navigating multiple support systems, which helped to identify important areas for investigation. However, the primary analytical framework was developed from existing literature on transfer student experiences, including transfer shock impacts (Smith et al., 2021), credit loss consequences (Monaghan & Attewell, 2015), and support system navigation challenges (Reeping & Knight, 2021).

Literature Review

The research initially explored engineering transfer pathways across multiple states, analyzing state-level policies, articulation agreements, ABET accreditation requirements, and engineering-specific pathways. This broad investigation identified structured transfer programs, such as Associate Degrees for Transfer (ADT), as promising solutions to prevent credit loss while maintaining academic standards in engineering programs.

Documentation

Data was collected and documented on the ADT framework for each of the programs in the following areas: prerequisite courses, lower division major requirements, general education requirements, total unit requirements for transfer, transfer timing eligibility, course sequencing requirements, credit evaluation processes to address credit loss and support transfer in engineering disciplines.

Findings

Comparative tables and visuals were used to analyze credit structures, advising requirements, sequence protection, and transfer guarantees across Indiana, Texas, and Washington. Focusing on these elements, the methodology identifies systemic factors that influence credit loss and time-to-degree outcomes in engineering education. Examine articulation agreements, course equivalency processes, and student support systems, focusing on how they may align student understanding with institutional requirements. The analysis aims to identify commonalities, unique strategies, and challenges across the selected states.

Comparative Analysis

Implications for California's Associate Degree for Transfer Framework:

This multi-state comparative analysis examines documented engineering pathways practices relevant to California’s existing ADT framework. The findings are evaluated to inform the state’s efforts in addressing credit loss and the improvement of transfer pathways for engineering students.

Best Practices that will address:

Workforce Development

- Addresses critical engineering shortages in California's technology sectors
- Supports regional industry needs through consistent graduate preparation
- Creating cost-effective pathways into engineering careers

Economic Benefits

- Strengthens community college and university partnerships
- Enhances economic mobility through structured transfer pathways
- Maintains California's global competitiveness in technology and innovation

Regional Outcomes

- Increases engineering graduate pipeline for local industry
- Expands access to engineering degrees across geographic regions
- Supports diversity in regional engineering workforce

Credit Loss Evaluation Criteria

To address the credit loss challenge, this methodology evaluates how each state's framework performs across the following dimensions: Minimizing redundant coursework, assessing the role of advising interventions, evaluating sequence protection policies, and identifying transferable features that reduce credit loss, such as guaranteed junior status or mandatory sequence advising.

Current Practices: Transfer Pathway

Indiana's Transfer Single Articulation Pathway (TSAP)

Program Structure:

The Transfer Single Articulation Pathway represents Indiana's statewide effort to streamline engineering transfers between Ivy Tech Community College, Vincennes University, and Indiana's public universities. TSAP provides a structured 60-credit framework with guaranteed junior status upon completion (Indiana Transfer Single Articulation Pathways, 2015). The program emphasizes competency-based learning outcomes while maintaining consistent course content and learning objectives across institutions.

Table 1: Indiana Transfer Single Articulation Pathway (TSAP) Framework

Core Components

Category	**Details**
Mathematics Sequence	Calculus I-III (MATH 211, 212, 261), Differential Equations (MATH 264), Linear Algebra (MATH 265)

Science Foundation	General Chemistry I (CHEM 105), Physics (PHYS 220, 221)
Engineering Core	Introduction to Engineering Design (ENGR 190), Thermodynamics (ENGR 200), Statics (ENGR 260), Dynamics (ENGR 261), Electrical Circuits I (ENGR 251)
General Education	30 credits including English Composition, Public Speaking, and Ethics

Implementations Features

Category	**Details**
Junior Status Guarantee	Students receive junior status upon completing 60 credits
Standardized Competency-Based Outcomes	Ensures consistency in learning objectives across institutions
Inter-Institutional Collaboration	Promotes alignment and partnership between Ivy Tech Community College, Vincennes University, and Indiana's public universities
Cost-Efficiency Emphasis	Estimated savings of up to $10,000 for students through streamlined transfer pathways

Table 1: Data compiled includes Core components and implementation features collected from Ivy Tech Community College Engineering Programs (n.d., retrieved January 2025), Indiana Senate Bill 182 (n.d., retrieved January 2025), and Transfer Single Articulation Pathways (2015).

Key Outcomes:

- Consistent learning outcomes across institutions
- Reduced credit loss through standardization
- Balanced general education component (50% of credits)
- Clear progression pathways for students

Table 2: Texas Foundational Engineering
Program Structure:

Texas implements a foundational engineering approach through guaranteed transfer agreements and standardized core requirements across its public institutions (Texas Education Code Chapter 88, n.d.). The framework emphasizes flexibility while maintaining rigorous preparation in core engineering competencies. Rather than a single degree pathway, Texas emphasizes standardized foundational requirements in mathematics, physics, and introductory engineering courses, allowing for program-specific customization (General Engineering Class of 2026 Requirements, n.d.). This flexibility enables students to complete core requirements before specializing in their chosen engineering discipline.

Table 2: Texas Foundational Engineering Framework

Core Components

Category	**Details**

Mathematics Sequence	MATH 151-152 (Calculus I, II), MATH 251/253 (Calculus III), MATH 308 (Differential Equations), Linear Algebra/Discrete Math (MATH 304/CSCE 222)
Science Foundation	PHYS 206-207, CHEM 107/117 or CHEM 119
Engineering Foundation	ENGR 102, ENGR 216
Program-Specific Requirements	Additional chemistry for specialized programs

Implementations Features

Category	**Details**
Flexible Transfer Timing	Allow students to meet foundational requirements at their own pace
Standardized Core Requirements	Ensures alignment across institutions for key engineering courses
Program-Specific Pathways	Supports specialized disciplines with tailored pathways
Guaranteed Transfer Programs	Recent expansions include ambitious partnerships like the Texas State and Collin College initiative

Table 2: Texas Foundational Engineering Framework: Data compiled includes Core components and implementation features collected from Texas A&M University Engineering Requirements (2024, retrieved January 2025), Texas Education Code Chapter 88 (retrieved January 2025), and Texas State and Collin College Transfer Program documentation (2024).

Key Outcomes:

- Enhanced alignment between two-year and four-year institutions
- Reduced redundancy in coursework
- Greater flexibility in transfer timing
- Focus on engineering preparation over general education

Washington AS-T Track 2

Program Structure:

Washington's AS-T Track 2 provides a 90-quarter-credit framework designed for engineering transfer students. The program incorporates transfer protection mechanisms, including sequence preservation requirements and clear course equivalencies through the ICRC Handbook (WSAC, 2020). Notable features include discipline-specific pathways for different engineering fields and mandatory academic advising to support student progress.

Table 3: Washington AS-T Track 2 Framework

Core Components

Category	**Details**
Mathematics	18-20 credits: Calculus sequence, Differential Equations, Linear Algebra

Physics	15-18 credits: Three-course sequence with labs
Chemistry	Program-specific requirements: 5-30 credits
General Education	15 credits minimum in Humanities and Social Sciences

Implementations Features

Category	**Details**
Sequence Preservation	Ensures course sequences remain intact during transfer
Mandatory Academic Advising	Requires students to receive advising to support successful transfer
Degree Coding System	Clear identification of transfer pathways using the PHST2AS coding system
Priority Admission	Provides priority consideration for admission to four-year institutions

Table 3: Washington AS-T Track 2 Framework: Data compiled includes Core components and implementation features collected from Intercollege Relations Commission Track 2 Agreement (2009, retrieved January 2025), Washington Student Achievement Council Transfers (n.d., retrieved January 2025), and Statewide Engineering AS-T 2/MRP Agreement (2020, retrieved January 2025).

Key Features:

- Includes transfer protection mechanisms such as sequence preservation, ensuring uninterrupted progress in engineering pathways.
- Guaranteed junior status for students meeting program requirements and priority admission consideration.
- Comprehensive student support framework, including mandatory advising and transfer monitoring.

Findings and Discussion

Comparative Analysis of State Engineering Transfer Frameworks

Table 4: Core Components of Analysis

Category	**Details**
Analysis type	Multi-state comparative analysis
Focus	Engineering Pathways
States analyzed	Indiana, Texas, Washington
Engineering fields	Mechanical, Civil, Electrical, Chemical, Aerospace
Data Sources	State documentation, articulation agreements, published research

Using the following criteria to evaluate credit loss; minimization of redundant coursework, the role of advising interventions, and evaluating sequence protection policies to identify transferable features for a California AD-T in engineering. The analysis examines three established engineering transfer frameworks: Indiana's Transfer Single Articulation Pathway (TSAP), which emphasizes competency-based outcomes and standardization; Texas's Foundational Engineering framework, which prioritizes flexibility and core preparation; and Washington's AS-T Track 2, which features sequence protection mechanisms. By examining how each framework addresses these critical aspects of engineering transfer pathways, we can identify effective practices that could enhance California's existing ADT structure while accounting for the unique challenges of engineering curricula.

Table 5: Comparison of Program Structures

Feature	**Indiana TSAP**	**Texas Framework**	**Washington AS-T**
Credit Structure	60 credits	Variable	90 credits
Junior Status	Guaranteed	Varies	Guaranteed
Gen Ed Credits	30 credits	Not Uniform	15 credits min
Math/ Science Core	38 credits	Core-focused	40-45 credits

Table 5 shows variations in program structures across the three states, showing different philosophies to credit loss prevention and transfer policy. Credit structures demonstrate distinct philosophies: Texas and Indiana use a fixed 60-credit semester / 90-quarter-credit framework, while Texas uses a variable credit structure. The analysis shows that while Indiana and Washington guarantee junior status upon transfer completion, Texas's variable approach offers flexibility with less certainty of transfer status. General education requirements vary substantially between states. Washington requires 15 credits compared to Indiana's 30-credit requirement, reflecting different priorities in curriculum balance.

Table 6: Key Feature

Component	**Indiana**	**Texas**	**Washington**
Advising Req'd	Yes	No	Yes
Sequence Protection	Partial	Limited	Strong
Transfer Guarantees	Full	Partial	Full
Course Equivalency	CTL System	Variable	ICRC Handbook

Table 6 highlights important differences in how each state implements transfer pathway protections and support systems. The analysis reveals a clear divide in advising approaches, with Indiana and Washington requiring mandatory advising interventions while Texas maintains optional advising support. Sequence protection mechanisms vary significantly: Washington demonstrates the strongest protection measures, Indiana implements partial protections through its CTL System, and Texas maintains limited sequence safeguards in favor of flexibility. Transfer guarantees align closely with these protective measures, with Indiana and Washington offering full transfer guarantees while Texas provides a partial guarantee.

Table 7: Detailed Component Comparison

Feature	Indiana TSAP	Texas Framework	Washington AS-T

Credit Structure	60 sem credits	Variable	90 qtr credits
Math Sequence	Calc I-III, DE, Linear Algebra	Calc I-III, DE, Linear/Discrete	Calc I-III, DE, Linear Algebra
Science Core	Chem I, Physics sequence	Physics, Some Chem	Physics series, Chem varies
Engineering Core	Design, Thermo, Circuits	Basic Eng, Foundation	Varies by discipline
Gen Ed Required	30 credits	Not uniform	15 credits min

Table 7 provides a detailed comparison of the three state’s credit priorities, revealing transfer philosophy and structure. Indiana and Washington maintain a fixed 60-credit semester / 90-quarter credit structure respectively, while the Texas Framework allows variable credit accumulation. General education requirements range from Washington's minimal approach (15 semester credits) to Indiana's requirement (30 quarter credits), while Texas maintains flexibility with non-uniform requirements. Math sequence requirements show alignment across all three states. The science core requirements have notable variation: Indiana specifies Chemistry I and a Physics sequence, while Texas emphasizes Physics with some Chemistry. Washington’s approach emphasizes flexibility in transfer requirements, fitting transfer requirements for core engineering courses and chemistry to each discipline based on specific engineering pathways. For example, Chemical Engineering requires the full General Chemistry sequence and Organic Chemistry sequence (23-30 credits), while other engineering disciplines like Mechanical or Civil require fewer chemistry credits (10-12 credits).

Table 8: Additional Features Comparison

Feature	Indiana	Texas	Washington
Junior Status	Guaranteed	Varies	Guaranteed
Advising Required	Yes	No	Yes
Sequence Protection	Partial	Limited	Strong
Transfer Guarantee	Full	Partial	Full
Course Equivalency	CTL System	Variable	ICRC Handbook
Cost Savings Est.	$10,000	Not specified	Not specified

The analysis of the data collected remains in progress. This phase focuses on evaluating the effectiveness of Associate Degrees for Transfer frameworks in Indiana, Texas, and Washington in addressing credit loss and transfer challenges within engineering pathways. Once the analysis is finalized, the findings will be presented to provide actionable insights into best practices and their applicability to California's context.

Methodological Limitations

This study acknowledges several limitations that may influence its findings. Transfer requirements and articulation agreements accessed through online sources may not reflect the most recent updates or policy changes. Furthermore, the reliance on publicly available documentation may have excluded proprietary or internal institutional practices that impact credit transfer processes. Finally, regional differences across state systems, shaped by distinct priorities and structures, may limit the applicability of these findings to California’s context.

Despite these limitations, the study provides valuable insights and highlights areas for future research.

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