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WIP: Implementing Early Momentum Metrics to Improve Retention in Engineering and Technology Programs

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Abstract

This work-in-progress paper examines the use of the Early Momentum Metrics (EMM) Framework as a strategy to improve student retention within the College of Engineering and Technology (CET) at a predominantly undergraduate institution. EMM indicators including gateway course completion, first-term credit momentum, and term-to-term persistence have been shown to be strong predictors of long-term student success, particularly in STEM fields. Analysis of institutional data from the Fall 2021–2023 cohorts revealed a fall-to-fall retention rate of 61.9% within the CET, substantially below the university average of 75.5%. Further examination identified completion of MATH 153 (Calculus 1) and enrollment in at least 15 credits during the first term as key predictors of persistence for Engineering Technology (ET) and Electrical and Computer Engineering Technology (ECET) majors.

In response to these findings, the CET is developing a pilot retention initiative which started implementation in Fall 2025. The initiative integrates targeted advising, early academic intervention, and belonging-centered programming. Core components include proactive outreach to students demonstrating early academic risk (e.g., unsatisfactory early-term grades or non-enrollment in MATH 153), peer-led community-building events, and structured advising practices designed to support students in achieving EMM milestones. This paper presents the logic model underpinning the proposed intervention and describes initial design features. Future phases of the project will evaluate the initiative's effectiveness in improving retention, credit momentum, and degree efficiency, contributing to broader efforts to meaningfully operationalize the EMM Framework in engineering education.

Introduction

Retention in undergraduate engineering and technology programs remains a persistent national challenge, particularly during the first year of enrollment. Despite increasing attention to access and enrollment, many engineering programs continue to experience substantial attrition in the early stages of the curriculum, when students encounter demanding gateway courses, complex degree pathways, and unfamiliar academic expectations [1], [2]. These early departures have significant implications not only for institutional performance metrics, but also for workforce development, equity, and students' long-term educational and economic outcomes.

At predominantly undergraduate institutions, retention challenges are often compounded by limited resources, high advising loads, and student populations that include a large proportion of first-generation, transfer, and regionally rooted students [3]. Within engineering and technology programs, early academic delays, such as unsuccessful completion of first-year mathematics or insufficient credit accumulation, can quickly disrupt curricular sequencing, increase time to degree, and erode students' confidence and sense of belonging. As a result, institutions are increasingly seeking data-informed, actionable frameworks that allow for early identification of risk and timely intervention.

The Early Momentum Metrics framework has emerged as a promising approach for understanding and improving student persistence by focusing on measurable academic behaviors in the first year of college [4]. Grounded in momentum theory, EMM emphasizes indicators such as gateway course completion, first-term credit accumulation, and continuous enrollment as strong predictors of long-term student success. Unlike deficit-based models that focus primarily on student background characteristics, EMM highlights institutional leverage points, particularly advising, course placement, and early academic support, that can be intentionally designed to promote student progress.

Engineering and technology programs are particularly well suited for EMM-informed interventions due to their structured curricula and reliance on prerequisite sequencing. However, while prior research has demonstrated the predictive power of early momentum indicators, fewer studies have documented how engineering colleges operationalize EMM within localized contexts or integrate these metrics into holistic, belonging-centered retention initiatives. There remains a need for work-in-progress research that details the design, implementation, and early monitoring of EMM-based interventions, especially at teaching-focused institutions.

This work-in-progress paper examines the application of the Early Momentum Metrics framework within the College of Engineering and Technology at a predominantly undergraduate institution. Institutional data from recent cohorts revealed fall-to-fall retention rates substantially below the university average, with early mathematics completion and first-term credit momentum emerging as key predictors of persistence for several engineering technology programs. In response, the CET developed a pilot retention initiative beginning in Fall 2025 that integrates targeted advising, proactive outreach, and community-building programming aligned with EMM principles.

The purpose of this paper is to present the logic model guiding the intervention, describe the initial implementation strategies, and share preliminary observations related to early momentum indicators. By documenting this early-stage work, the study aims to contribute practical insight into how EMM can be operationalized in engineering and technology contexts, while inviting feedback from the engineering education community as the project continues to evolve.

Literature Review

Persistence in Engineering

Academic preparation and performance are among the strongest predictors of engineering persistence. Performance in early technical courses such as calculus, physics, and introductory engineering, significantly influences whether students continue in the major [5]. Predictive modeling research has demonstrated that first-term GPA, high school preparation, and performance in gateway STEM courses reliably predict retention outcomes [5].

Academic self-efficacy, or students’ confidence in their ability to succeed academically, is also closely tied to persistence. Students who feel capable of mastering engineering tasks are more likely to continue, even if their performance is not initially strong [6].

Sense of Belonging and Engineering Identity Development

Beyond academic indicators, psychosocial variables like belonging and engineering identity, meaningfully influence persistence. A study by Marra et al. [7] investigated factors influencing students leaving engineering, and sense of belonging and support from faculty were major impacts. Belonging interventions that normalize academic struggle and encourage help-seeking have been shown to support continued enrollment in early engineering courses [8]. These interventions help students feel connected to their peers and faculty.

A strong sense of belonging is a critical factor influencing students' interest, persistence, and overall success in engineering. Research consistently demonstrates that involvement in organizations and societies designed to support Under-Represented Minority (URM) students contributes significantly to their sense of belonging and persistence within engineering pathways [9], [10], [11], [12], [13]. These affinity-based groups often provide community, validation, and culturally responsive support structures that help counteract the marginalization many URM students experience in engineering contexts.

In addition to affinity organizations, engineering learning communities have been shown to positively affect student outcomes. Studies indicate that participation in these communities enhances retention and graduation rates [14] while also strengthening students' sense of belonging, confidence, and identity development [11], [15], [16], [17]. The literature further highlights the role of interpersonal relationships in fostering belonging. Faculty and peer mentoring have been identified as influential mechanisms that support URM students' sense of belonging and contribute to their engineering identity development [11], [15].

Engineering identity research suggests that students who see themselves as engineers, and who feel recognized by others as such, are more likely to persist [6], [18]. Identity development is especially critical for historically marginalized students in engineering, who may face isolation or stereotype threat.

Identity encompasses both how individuals perceive themselves and how they are perceived by others. Within engineering education, an engineering identity is commonly understood to emerge through students' interest in engineering, the recognition they receive from others, and their perceived competence or performance in the field [18], [19]. The construct of identity has received increasing scholarly attention in recent years, particularly due to its relevance to the development of the engineering profession and its intersections with key issues such as student retention, educational climates, and the experiences of underrepresented groups [20]. A substantial body of work has examined engineering persistence specifically, as highlighted by Choe et al. [21], Godwin and Lee [19], and Morelock [20]. Persistence is a critical area of study because of its implications for both educational trajectories and long-term vocational outcomes [18], [22], [23], [24], [25], [26], [27], [28], [29].

External contextual factors such as campus climate and the broader culture of engineering also shape students' identity formation. Prior work demonstrates that campus culture can influence how students engage in engineering spaces and even how project teams function [10], [22], [23], [30], [31]. Tonso [23], for example, argued that the organizational and cultural structure of engineering programs significantly informs students' identity experiences within project teams.

Recent work has also highlighted the influence of engineering culture on student well-being, noting that the high-stress environment of engineering programs contributes to elevated levels of anxiety and depression among students [32]. Collectively, these findings suggest that engineering culture plays a central role in shaping engineering identity and, consequently, persistence within the discipline.

The Role of Advising in Engineering

Various interventions have been tested in engineering in order to support retention efforts. At the program level, advising models, mentoring initiatives, and inclusive pedagogies significantly shape the student experience. Waller [33] found that institutional structures, including advising availability and departmental culture, directly affect engineering persistence. These structural factors may interact with academic and psychosocial variables, amplifying or mitigating student challenges.

Academic advising plays a critical role in engineering education, influencing student retention, academic success, professional identity formation, and diversity within the field. Strong advising contributes to students' academic and social integration, concepts central to persistence models such as Tinto's [34] theory of student departure. Retention in engineering remains a national concern, with many departures occurring in the first two years. Advising provides clarity around complex degree pathways, reduces time-to-degree, and supports student confidence- all factors linked to persistence [35]. Meaningful advising interactions increase student involvement and institutional connection, two factors associated with continued enrollment according to Astin's involvement theory and Tinto's integration framework [34].

In engineering, prescriptive advising often dominates because of structured prerequisite chains. However, research shows that prescriptive approaches alone fail to support the holistic growth students need. Developmental advising, which emphasizes goal-setting, personal development, and mentoring, creates stronger student motivation and long-term planning skills [36]. These developmental approaches are particularly helpful for engineering students navigating demanding curricula.

Engineering identity has emerged as a significant predictor of persistence. Advisors who reinforce belonging, expose students to engineering experiences, and encourage career exploration help students develop stronger engineering identities [18]. This is especially important for students from underrepresented groups, who may face stereotype threat or limited access to informal mentoring networks [35]. Advisors play a key role in connecting students with undergraduate research, internships, and pathways toward licensure; factors that strengthen professional identity and long-term persistence [18].

Engineering programs use varied advising structures, including centralized professional advisors, faculty advisors, and first-year advising units. Evidence suggests hybrid models combining faculty expertise with professional advising support yield the strongest results [36]. Despite these benefits, common challenges persist, including high advisor-to-student ratios, inconsistent advisor training, and heavy reliance on students' self-advocacy [35].

Together, these studies underscore the interconnectedness of community, mentorship, and structured support programs in cultivating a sense of belonging and identity development that is foundational to student persistence in engineering.

Early Momentum Metrics

The Early Momentum Metrics was utilized by the authors as a strategic method to improve engineering retention and persistence at Western Carolina University. EMM has emerged as a prominent framework for understanding and improving student persistence and completion in higher education, particularly within STEM disciplines. Rooted in momentum theory, EMM emphasizes the importance of students' early academic progress, especially during the first year, as a strong predictor of long-term success [37], [38]. Rather than focusing solely on background characteristics or isolated interventions, EMM centers on actionable academic behaviors and milestones that institutions can influence through policy, advising, and program design.

A core premise of the EMM framework is that early academic momentum, defined through measurable indicators such as credit accumulation, gateway course completion, and continuous enrollment, significantly increases the likelihood of degree completion [4], [37], [39], [40]. Adelman's [37] seminal work demonstrated that earning at least 20 credits in the first year (particularly in academically rigorous coursework) was one of the strongest predictors of bachelor's degree attainment, surpassing traditional demographic variables. Subsequent studies reinforced these findings, showing that students who maintain steady academic progress early in their college careers are more resilient to later academic challenges [38].

Within the EMM framework, gateway course completion has received particular attention, especially in STEM fields where early mathematics and science courses often serve as barriers to persistence. Research consistently shows that successful completion of first-year mathematics courses such as college algebra, precalculus, or calculus is strongly associated with continued enrollment and degree completion in engineering and related disciplines [41], [42]. Failure to complete these courses on time can delay progression, increase cognitive and financial burden, and ultimately lead to attrition. As a result, EMM analyses frequently identify early math performance as a critical leverage point for intervention.

Credit momentum, often operationalized as enrollment in and completion of 15 or more credits per term, is another key EMM indicator. Studies have found that students who attempt and successfully complete higher credit loads early are more likely to graduate on time and less likely to stop out, even after controlling for academic preparation [4], [43]. Importantly, this relationship holds across institutional types and student populations, suggesting that early credit accumulation functions as both a structural and motivational mechanism that supports persistence.

Term-to-term persistence, particularly from the first to second year, is also central to the EMM framework. Research indicates that students who maintain continuous enrollment without gaps are significantly more likely to complete their degrees [44]. Early disruptions such as course withdrawal, part-time enrollment, or stop-out can erode academic momentum and increase the likelihood of departure, especially for students in demanding STEM programs.

In engineering education specifically, the application of EMM has gained traction as institutions seek data-informed strategies to address persistent retention challenges. Engineering programs are particularly well-suited for EMM-informed approaches due to their structured curricula, reliance on prerequisite sequencing, and sensitivity to early academic delays [45]. Integrating EMM with engineering-specific practices like cohort models, learning communities, and early design experiences has the potential to support both academic momentum and students' sense of belonging, further reinforcing persistence.

Overall, the literature positions Early Momentum Metrics as a powerful, actionable framework for improving student retention and degree completion. By focusing on early, measurable academic milestones, EMM provides institutions, specifically engineering, with clear leverage points for intervention. When paired with intentional advising, academic support, and belonging-centered strategies, EMM offers a promising pathway for advancing both student success and equity in engineering education, thus our team built a tool dashboard with institutional data to measure the momentum metrics of our engineering students, and we began monitoring our interventions.

Methodology

The methodology for this initiative is grounded in a cohort analysis designed to evaluate the effectiveness of specific advising and belonging interventions. The study follows first-time, full-time students (per IPED standards) within the College of Engineering and Technology who have declared majors in Engineering, Electrical Engineering, Electrical and Computer Engineering, or Engineering and Technology. Students are officially assigned to a retention cohort after the census date. Notably, Construction Management majors are excluded from the study because their curriculum does not require MATH 153 (Calculus 1), which the project identifies as a crucial gateway indicator for engineering persistence.

To analyze the impact of interventions, the study employs a treatment matrix that categorizes students into four distinct groups based on their level of engagement:

- Full Treatment: 2+ advising/support interactions AND 2+ belonging interactions.
- Advising/Support Only: 2+ advising interactions but 0–1 belonging interactions.
- Belonging Only: 2+ belonging interactions but 0–1 advising interactions.
- No Treatment: 0–1 interaction of either type.

Interventions are tracked through a comprehensive Success Measures Dictionary. This tool provides operational definitions for each metric, explains their significance, and establishes advising action timelines to ensure interventions are timely. The project identifies at-risk students as those with two or more unsatisfactory grades by the fifth week or those not attempting MATH 153. The evaluation framework compares current data against baseline measures from Fall 2021–2023 averages for second- and third-term retention. The team intends to continue tracking these cohorts through Fall 2030 to build a robust dataset for long-term analysis.

Preliminary Findings

Although we are early on in our study, some preliminary results have been found. With starting the interventions with the Fall 2025 cohort, there has been an increase in 2nd term progression from an average of 62.2% over the years of 2021-2024, to roughly 90.6% retention for Fall 2025. With this study, we will monitor cohorts starting in 2025 through their completed graduation, and the following cohorts (2026, 2027, 2028, 2029, and 2030), to assess implementation effectiveness of the interventions completed.

Future Work

Students' access to advising has increased with the implementation of the Engineering Discovery program that is located in the same building as CET courses and with the addition of one academic advisor. The number of advising appointments increased from 343 to 542 from Fall 2024* to Fall 2025. Although the number of appointments has increased, the at-risk students are more likely to attend group registration sessions rather than one-on-one and less likely to attend the advising intervention meetings that are optional. Future work will include identifying more opportunities to engage with at-risk students including proactive outreach prior to their first-term as well as increasing communication efforts to increase participation.

**Please note, Fall 2024 was impacted by Hurricane Helene and the university closed for a period.*

References

[1] ASEE, “Engineering & Technology by The Numbers,” 2024.

[2] X. Chen, “STEM Attrition: College Students’ Paths into and out of STEM Fields. Statistical Analysis Report. NCES 2014-001,” National Center for Education Statistics, Nov. 2013. Accessed: Apr. 28, 2026. [Online]. Available: https://eric.ed.gov/?id=ED544470

[3] AAC&U, “Diversity, Equity, and Student Success Conference,” *Resources*, 2019, [Online]. Available: https://commons.lib.jmu.edu/resources/149

[4] C. R. Belfield, D. Jenkins, and J. Fink, “Early Momentum Metrics: Leading Indicators for Community College Improvement. CCRC Research Brief,” Community College Research Center, Jul. 2019. Accessed: Jan. 07, 2026. [Online]. Available: https://eric.ed.gov/?id=ED596315

[5] D. P. Kelly, J. V. Ernst, A. C. Clark, and E. Schettig, “Understanding Factors of Engineering Student Persistence Using Predictive Modeling,” presented at the 2021 ASEE Virtual Annual Conference Content Access, Jul. 2021. Accessed: Jan. 20, 2026. [Online]. Available: https://peer.asee.org/understanding-factors-of-engineering-student-persistence-using-predictive-modeling

[6] M. Quezada-Espinoza, M. E. Truyol, and C. Zapata-Casabon, “Predictors of Success and Retention: The Influence of Belonging and Self-Efficacy on First-Year Engineering Students,” presented at the 2025 ASEE Annual Conference & Exposition, Jun. 2025. Accessed: Apr. 28, 2026. [Online]. Available: https://peer.asee.org/predictors-of-success-and-retention-the-influence-of-belonging-and-self-efficacy-on-first-year-engineering-students

[7] Marra et al., “Leaving Engineering: A Multi-Year Single Institution Study.” Accessed: Jan. 20, 2026. [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/j.2168-9830.2012.tb00039.x

[8] M. Bahnson, A. Godwin, C. Schunn, E. McChesney, and L. DeAngelo, “Retention in engineering pathways: an ecological belonging intervention supports help-seeking and continued enrollment,” *Int. J. STEM Educ.*, vol. 12, no. 1, p. 6, Feb. 2025, doi: 10.1186/s40594-025-00530-w.

[9] D. Dortch and C. Patel, “Black Undergraduate Women and Their Sense of Belonging in STEM at Predominantly White Institutions,” *NASPA J. Women High. Educ.*, vol. 10, no. 2, pp. 202–215, 2017, doi: http://dx.doi.org/10.1080/19407882.2017.1331854.

[10] L. N. Fleming, K. C. Smith, D. G. Williams, and L. B. Bliss, “Engineering identity of Black and Hispanic undergraduates: The impact of minority serving institutions,” in *ASEE Annual Conference & Exposition*, 2013.

[11] E. Liptow, K. Chen, R. Parent, J. Duerr, and D. Henson, “A Sense of Belonging: Creating a Community for First-generation, Underrepresented groups and Minorities through an Engineering Student Success Course,” in *Paper presented at the ASEE Annual Conference & Exposition Proceedings*, New Orleans, Louisiana: ASEE Conferences, Jun. 2016, p. 26439. doi: 10.18260/p.26439.

[12] E. Litzler and C. Samuelson, “How Underrepresented Minority Engineering Students Derive a Sense of Belonging from Engineering,” in *Paper presented at the ASEE Annual Conference & Exposition Proceedings*, Atlanta, Georgia: ASEE Conferences, 2013, p. 23.674.1-23.674.20. doi: 10.18260/1-2--19688.

[13] C. Mooney and B. A. Becker, “Sense of Belonging: The Intersectionality of Self-Identified Minority Status and Gender in Undergraduate Computer Science Students,” in *United*

Kingdom & Ireland Computing Education Research conference., Glasgow United Kingdom: ACM, 2020, pp. 24–30. doi: 10.1145/3416465.3416476.

[14] K. G. Ricks, J. A. Richardson, H. P. Stern, R. P. Taylor, and R. A. Taylor, "An Engineering Learning Community To Promote Retention And Graduation Of At-Risk Engineering Students," *Am. J. Eng. Educ. AJEE*, vol. 5, no. 2, pp. 73–90, Nov. 2014, doi: 10.19030/ajee.v5i2.8953.

[15] M. Ahmed, T. J. Muldoon, and M. Elsaadany, "Employing Faculty, Peer Mentoring, and Coaching to Increase the Self-Confidence and Belongingness of First-Generation College Students in Biomedical Engineering," *J. Biomech. Eng.*, vol. 143, no. 121001, Sep. 2021, doi: 10.1115/1.4051844.

[16] G. A. Dietz, "A narrative exploration of the influences of internship experiences on the identities of Black engineers," University of Florida, Gainesville, Fl, 2022.

[17] G. A. Dietz, K. J. Kummerlen, and E. P. Douglas, "Work in Progress: An Autoethnographic Account of a Female Engineering Intern," presented at the ASEE Annual Conference Proceedings, Jul. 2021. Accessed: Aug. 25, 2021. [Online]. Available: https://peer.asee.org/work-in-progress-an-autoethnographic-account-of-a-female-engineering-intern

[18] A. Godwin, "The Development of a Measure of Engineering Identity," *ASEE Annu. Conf. Expo.*, Jan. 2016, doi: 10.18260/p.26122.

[19] A. Godwin and W. Lee, "A Cross-sectional Study of Engineering Identity During Undergraduate Education," in *2017 ASEE Annual Conference & Exposition Proceedings*, Columbus, Ohio: ASEE Conferences, Jun. 2017. doi: 10.18260/1-2--27460.

[20] J. R. Morelock, "A systematic literature review of engineering identity: definitions, factors, and interventions affecting development, and means of measurement," *Eur. J. Eng. Educ.*, vol. 42, no. 6, pp. 1240–1262, Nov. 2017, doi: 10.1080/03043797.2017.1287664.

[21] N. H. Choe, L. L. Martins, M. Borrego, and M. R. Kendall, "Professional Aspects of Engineering: Improving Prediction of Undergraduates' Engineering Identity," *J. Prof. Issues Eng. Educ. Pract.*, vol. 145, no. 3, p. 04019006, Jul. 2019, doi: 10.1061/(ASCE)EI.1943-5541.0000413.

[22] K. L. Tonso, "Teams that Work: Campus Culture, Engineer Identity, and Social Interactions," *J. Eng. Educ.*, vol. 95, no. 1, pp. 25–37, 2006, doi: 10.1002/j.2168-9830.2006.tb00875.x.

[23] K. L. Tonso, "Student Engineers and Engineer Identity: Campus Engineer Identities as Figured World," *Cult. Stud. Sci. Educ.*, vol. 1, no. 2, pp. 273–307, Sep. 2006, doi: 10.1007/s11422-005-9009-2.

[24] B. M. Capobianco, B. F. French, and H. A. Diefes-Du, "Engineering Identity Development Among Pre-Adolescent Learners," *J. Eng. Educ.*, vol. 101, no. 4, pp. 698–716, 2012, doi: 10.1002/j.2168-9830.2012.tb01125.x.

[25] Matusovich, H. M., Barry, B. E., Meyers, K., & Louis, R., "A multi-institution comparison of students' development of an identity as an engineer.," presented at the 118th ASEE Annual Conference & Exposition, Vancouver, Canada., 2011.

[26] J. Jorgenson, "Engineering Selves: Negotiating Gender and Identity in Technical Work," *Manag. Commun. Q.*, vol. 15, no. 3, pp. 350–380, Feb. 2002, doi: 10.1177/0893318902153002.

[27] X.-Y. Du, “Gendered practices of constructing an engineering identity in a problem-based learning environment,” *Eur. J. Eng. Educ.*, vol. 31, no. 1, pp. 35–42, Mar. 2006, doi: 10.1080/03043790500430185.
[28] K. L. Meyers, M. W. Ohland, A. L. Pawley, S. E. Silliman, and K. A. Smith, “Factors relating to engineering identity,” *Glob. J. Eng. Educ.*, vol. 14, no. 1, p. 13, 2012.
[29] D. Chachra, D. Kilgore, H. Loshbaugh, J. McCain, and H. Chen, “Being and Becoming: Gender and Identity Formation of Engineering Students. Research Brief.,” *Cent. Adv. Eng. Educ. NJ1*, p. 3, 2008.
[30] A. L. Pawley, “Work in progress: Engineering identity markers in faculty members,” presented at the Research in Engineering Education Symposium, Davos, Switzerland, 2008.
[31] H. Stonyer, “Making Engineering Students Making Women: The Discursive Context of Engineering Education,” *TEMPUS Publ.*, vol. 18, no. 4, p. 8, 2002.
[32] K. J. Jensen and K. J. Cross, “Engineering stress culture: Relationships among mental health, engineering identity, and sense of inclusion,” *J. Eng. Educ.*, vol. 110, no. 2, pp. 371–392, 2021, doi: 10.1002/jee.20391.
[33] D. R. Waller, “ORGANIZATIONAL FACTORS AND ENGINEERING STUDENT PERSISTENCE,” thesis, Purdue University Graduate School, 2022. doi: 10.25394/PGS.21606342.v1.
[34] V. Tinto, *Leaving College: Rethinking the Causes and Cures of Student Attrition*. University of Chicago Press, 1994. doi: 10.7208/chicago/9780226922461.001.0001.
[35] B. N. Geisinger and D. R. Raman, “Why They Leave: Understanding Student Attrition from Engineering Majors,” vol. 29, 2013, Accessed: Apr. 28, 2026. [Online]. Available: https://www.researchgate.net/publication/285588323_Why_They_Leave_Understanding_Student_Attrition_from_Engineering_Majors
[36] B. B. Crookston, “A developmental view of academic advising as teaching,” *J. Coll. Stud. Pers.*, vol. 13, no. 1, pp. 12–17, 1972.
[37] C. Adelman, “THE TOOLBOX REVISITED- Paths to degree completion from high school through college,” 2006.
[38] P. Attewell, S. Heil, and L. Reisel, “What Is Academic Momentum? And Does It Matter?,” *Educ. Eval. Policy Anal.*, vol. 34, no. 1, pp. 27–44, Mar. 2012, doi: 10.3102/0162373711421958.
[39] J. Fink, T. Myers, D. Sparks, and S. Smith Jaggars, “Toward a Practical Set of STEM Transfer Program Momentum Metrics,” *Res. High. Educ.*, vol. 65, no. 2, pp. 259–282, Mar. 2024, doi: 10.1007/s11162-023-09759-2.
[40] X. Wang, “Pathway to a baccalaureate in STEM fields: Are community colleges a viable route and does early STEM momentum matter?,” *Educ. Eval. Policy Anal.*, vol. 37, no. 3, pp. 376–393, 2015, doi: 10.3102/0162373714552561.
[41] X. Chen and M. Soldner, “STEM Attrition: College Students; Paths Into and Out of STEM Fields,” 2013.
[42] K. Rask, “Attrition in STEM fields at a liberal arts college: The importance of grades and pre-collegiate preferences,” *Econ. Educ. Rev.*, vol. 29, no. 6, pp. 892–900, Dec. 2010, doi: 10.1016/j.econedurev.2010.06.013.
[43] Complete College America, “The Power of 15 Credits: Enrollment Intensity and Postsecondary Student Achievement,” 2014.
[44] P. Attewell and D. Monaghan, “How Many Credits Should an Undergraduate Take?,” *Res. High. Educ.*, vol. 57, no. 6, pp. 682–713, 2016, doi: 10.1007/s11162-015-9401-z.

[45] M. W. Ohland, S. D. Sheppard, G. Lichtenstein, O. Eris, D. Chachra, and R. A. Layton, "Persistence, Engagement, and Migration in Engineering Programs," *J. Eng. Educ.*, vol. 97, no. 3, pp. 259–278, 2008, doi: 10.1002/j.2168-9830.2008.tb00978.x.