Literature Brief

October 2025

# STEM Pathways and Community College Student Decision-Making

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## Introduction

This brief synthesizes literature on science, technology, engineering, and mathematics (STEM) pathways and community college student decision-making, beginning by documenting growth in STEM education. From 2012 to 2021, the total number of credentials in science and engineering fields rose from 982,000 to 1,310,000,[1] and community colleges played an increasingly important role in STEM education during this period. In 2021, community colleges awarded 50 percent of the 79,000 certificates and 76 percent of the 155,000 associate degrees in STEM education in the United States.

As STEM education has grown, so has our understanding of how community college STEM pathways work, what opportunities they offer diverse groups of students, and what employment opportunities they provide to graduates. Recognizing that learning is optimized when educational systems are designed to meet students' needs is fundamental to the STEM pathway approach. To be successful, this vision of student learning and development benefits from strategically aligned programs and services beginning in K-12 education and continuing through postsecondary education to employment.[2,3]

Building on this perspective, the National Academy of Sciences, Engineering, and Medicine[4] defines STEM pathways as follows:

> [T]he notion of "pathways" describes the numerous ways learners move between different STEM learning experiences across different settings and how these varied experiences can contribute to the development of proficiency in STEM disciplines, perceptions of the disciplines, and a sense of competence and identity in STEM[5].

## Why Focus on STEM Pathways?

A growing body of research on STEM education and various pathway approaches literature, including studies addressing the expansive nature of STEM education at all levels of education;[6]

STEM-focused teaching and learning processes;[7,8] linear and nonlinear transitions and flows of students through STEM education;[9] participation, transfer, and completion of STEM credentials by diverse student populations;[10,11,12,13] and the relationships between education and the STEM workforce.[14,15,16,17,18,19] These studies confirm the importance of envisioning STEM education as pathways that facilitate meaningful teaching and learning processes; inclusive student participation; and positive educational outcomes that lead to living-wage employment and career progression.

Moreover, this view of pathways should be distinguished from the notion of pipelines or tracks to more accurately acknowledge that students engage in STEM education in many different and multifaceted ways, such as when they choose and sometimes also change college majors as they advance toward a STEM degree, and when they change jobs as they progress in STEM careers. Effective STEM pathways do not force students onto inflexible linear tracks but instead recognize that students are more likely to succeed when they understand how STEM pathways work and are supported in making good decisions about their near- and long-term future. The concept of student agency is important to ensuring that students experiencing STEM pathways engage in transformative learning and successful outcomes.[20]

# STEM Student Pathways

The "pathways" term is not unique to STEM education. Across educational systems in this country and internationally,[21] the idea of student pathways has taken hold to recognize the varied ways students can achieve success in navigating educational systems. Pathways encompass formal and informal educational programming, support services, and resources that enable students to pursue STEM credentials and enter and progress in the labor force. STEM pathways intentionally support student decision-making in pursuit of majors and credentials that are well-suited to their aspirations to achieve positive education and employment outcomes.[22] To this end, the Community College S-STEM Network (CCSN) centers its research and development efforts on STEM student pathways that lead to upward mobility and economically secure workforce and career options. Following are brief discussions of three STEM pathway approaches that are consistent with the CCSN vision of STEM student success.

## STEM transfer pathways

One way the term "pathways" is used is in relation to the vertical transfer of community college students to universities that confer bachelor's degrees in STEM education. This application of

pathways to the transfer process emphasizes community college student matriculation and progression through community college and university-level studies to attain a baccalaureate degree.[23,24,25] STEM transfer pathways also emphasize factors that influence the ways in which students succeed in amassing college credits that count toward a bachelor's degree and in avoiding credit loss across the 2- and 4-year college spectrum. Envisioning the student's entire undergraduate learning experience, from starting at the community college to completing the baccalaureate, contributes to student persistence and degree completion.

## STEM career pathways

STEM career pathways convey intentional connections between secondary and postsecondary programs and credentialing, with strong emphasis on career development and preparation for employment. Connecting academic and career-technical education (CTE), including experiential and work-based learning, to credentials needed for employment, STEM career pathways offer a logical method of preparing students for STEM careers.[26,27] This purposeful overlap of STEM and CTE is important to students who want to see a direct link between their coursework and preparation for employment. To this end, Wang[28] notes STEM and CTE graduates often pursue employment in similar industry sectors and sometimes in similar occupations, which reinforces the importance of coordinating programmatic options across STEM education.

## Guided pathways

The guided pathways framework is especially relevant to the community college context.[29] This model emphasizes whole-college reform to support student success in community college with a clear set of education and career goals guiding students' way. Whereas not focused on STEM education specifically, the notion of guided pathways applies to STEM education just like the rest of the community college curriculum. Four areas of practice embedded in this framework are: 1) clarifying paths to student end goals, 2) helping students to get on a program path, 3) keeping students on a path, and 4) ensuring that students are learning across programs.[30] Researchers at the Community College Research Center (CCRC) are currently evaluating the potential for guided pathways reforms to increase undergraduate STEM student success, including studying a set of metrics potentially useful in assessing the effectiveness of STEM transfer pathways.[31]

# Elements of Community College STEM Pathways

Looking at these various ways pathways are associated with STEM education in the community college, we see some similar elements regardless of whichever approach is used (e.g., transfer pathway, career pathway, or guided pathway), although we do see some differences in priority. For example, transfer pathways tend to emphasize the articulation of course credits; proactive student supports, especially advising; and undergraduate research whereas career pathways emphasize applied learning, work-based learning, high-value credentials, and partnerships with industry.

These findings are reinforced by a systematic literature review conducted by CCSN researchers, Maria Espino and Elizabeth Meza, on STEM pathways offered by community colleges awarded NSF S-STEM scholarship grants.[32] This literature review examined community college S-STEM scholarship program design, including student cohorts, mentoring, undergraduate research, co-curricular student supports, and student outcomes. The brief explores these same elements in the literature about STEM education in the community college more generally, including delving into ways STEM pathways are designed for diverse student populations:

- Support for student planning and goal setting that promotes clarity and purpose in the choice of a STEM major, individual pursuits, and career preparation.[33,34,35]
- Program designs that include student cohorts, learning communities, and other institutional structural strategies that promote academic and social integration.[36,37]
- Corequisite developmental education models that help students overcome academic challenges in gateway math and English.[38,39]
- Inclusive and culturally relevant pedagogy that validates marginalized-identity students as authentic and valued learners in STEM.[40,41]
- Integration of high-value credentials in STEM pathways that enable students to demonstrate competencies mastered along their educational journey.[42,43]
- Transfer pathways that reduce barriers to successful student transition between institutions and cultivate STEM student baccalaureate attainment.[44,45]
- Proactive advising and holistic programs, services, and resources that support student success in STEM pathways.[46,47,48]

- Supplemental instruction and tutoring that promotes student academic achievement, persistence, and success in STEM.[49,50]
- Experiential and work-based learning that enables students to prepare to enter and progress in STEM careers.[51,52]
- Undergraduate research and course-based undergraduate research experiences (CUREs) that facilitate STEM career preparation and development.[53,54]
- Financial aid, loans, scholarships, and financial literacy about how money, knowledge, and resources can help students complete college.[55,56,57]
- Mentoring by faculty, staff, students, and industry partners that is carefully targeted to meet STEM student needs.[58,59,60]
- Integration of student sense of belonging and science identity throughout the learning process in STEM.[61,62,63]
- Partnerships with industries and employers to encourage and support STEM student transition to and progression within and across labor markets.[64,65]

When STEM pathways are strategically designed with these key elements in mind, the research shows community college students are more likely to succeed.

The next section of this brief goes deeper into literature pertaining to college student decision-making about STEM, emphasizing research on community college students in STEM pathways.

## Student Decision-Making About STEM

Studies of student decisions to attend college and choose majors have existed for decades. An early and well-studied model by Hossler and Gallagher[66] describes three phases of the college choice process beginning with a student's predisposition toward college, extending to the search for an institution that fits the student's college and career goals, and ultimately, the student's college selection. Perna's college access and choice model[67] adds depth and breadth to Hossler and Gallagher's framework by recognizing the expansive nature and complexity of college student decision-making. This model hypothesizes four contextual levels that interact to influence college student decisions: 1) individual habitus, referring to individual dispositions and

behaviors that are shaped by social background and experience; 2) school and community context, 3) higher education context, and 4) social, economic, and policy context. Drawing on sociological theories, Perna argues these four contexts shape students' understanding of and perspectives toward college and careers.

Recognizing their value to understanding college student decision-making, these models focus mainly on students of traditional age. With an average age of 27,[68] community college students can be seen as post-traditional in that they are part of a growing population of older college students whose families have limited or no prior experience with higher education. Knowing post-traditional students make up a substantial proportion of learners pursuing STEM pathways in community colleges, it is important to consider their decision-making processes. These post-traditional students also make decisions about what college and university to attend, what major to choose, and what career to pursue.[69] The decisions these students make about college are not made in isolation but built on fuller life experiences than traditional-age students.[70] Thus, they are affected by accumulated knowledge, aspirations, and dispositions. Embracing this view of post-traditional students is important to understanding the decisions students make about STEM pathways in community colleges.

Research on decision-making also recognizes the ways student capabilities influence college-going priorities. Most students but especially adult learners have opinions about college pursuits that interest them and that may benefit them.[71,72] Research also points to the importance of students voicing their points of view and advocating for themselves. Closely aligned with this perspective are theories that link individual decision-making to career development, such as social cognitive career theory.[73] This theory helps explain how student decisions to pursue a college major are rooted in self-efficacy in relationship to formulating educational goals and pursuing a career. Three factors core to this model are: "self-efficacy (can I do this?), outcome expectations (what will happen if I do this?), and personal goals (how much do I want to do this?)" Studies using this model show self-efficacy and individual expectation of outcomes influences student college and career choices.[74,75]

Wickersham[76] used grounded theory to study and develop a college choice model that accounts for the expansiveness of community college student populations and the array of choices these students make as they navigate college. Similar to Perna's college access and choice model, Wickersham's model recognizes the decisions post-traditional community college students make are linked to a multitude of contexts and factors that begin with student perceptions of post-graduation rewards. This research suggests community college students tend to select colleges

and college majors that they believe will secure employment in careers that "pay off".[77] Because economic outcomes are important to these students, they tend to choose a college major (e.g., STEM pathway) that fits well with their primary career interests and aspirations.

Another important feature of Wickersham's study is recognition that community college students engage in transfer. In vertical transfer specifically, students begin at a community college and transition to a baccalaureate-conferring institution to complete a bachelor's degree. Among many factors contributing to student decisions about vertical transfer is understanding how their chosen community colleges and universities work together to transfer course credits that count toward bachelor's degrees.[78] Transparency in how vertical transfer works in specific community colleges and universities is critical to transfer student decision-making that leads to baccalaureate attainment.[79]

Wickersham's findings also emphasize the importance of understanding the geographic location of community college students. This research reveals the high priority many of these students place on maintaining strong connections to the place they were raised and where they continue to live and work in adulthood. However, this study also found some community college students seek opportunities to relocate to attend college and pursue careers farther from home. In terms of student preferences for college-going, this study also reveals the decisions some students make about college-going are influenced by personal preferences for flexibility in instructional modalities.

## Community College Student Decision-making about STEM

Recent research on community college students' decisions to pursue STEM pathways reflects many elements of the abovementioned college choice and decision-making models, but unique features emerge in the STEM-specific literature. For example, some students pursuing community college STEM pathways must complete developmental (or remedial), including college-level mathematics, before progressing to more advanced coursework.[80,81] Understanding how coordinated relationships between K-12 and community college education can lead to greater student success in STEM pathways, including more success in transfer and baccalaureate attainment.[82,83,84] Thus, advancements in developmental education, including co-requisite curriculum, instruction, and supports, are important to community college students achieving successful outcomes in STEM education.

In addition, a substantial amount of research on STEM pathways in community colleges delves into the experiences and outcomes of marginalized-identity student populations, including Hispanic and Latine students who attend these institutions.[85,86,87] Community colleges enroll the highest proportion of Hispanic and Latine students of any level of 2-year, 4-year, or graduate education, and they also enroll large numbers of first-generation college students and students with limited personal and family income to pay for college. Research on the decisions these students make about college looks at how demographic and background characteristics influence STEM pathway enrollment, persistence, and completion.[88,89] Many of these studies examine how asset-focused theories and frameworks, such as community cultural wealth,[90] can be applied to STEM education in community colleges. Many examples of these studies exist in the literature, including qualitative studies examining how Latinx students navigate and experience success in pursuing STEM pathways.[91]

## Conclusions and Recommendations

Community colleges play an important role in STEM education, including guiding students in decision-making to engage, persist, and complete STEM pathways. No doubt more research is needed to more fully understand STEM pathways and student decision-making in the community college context, this brief advances understanding of community college student decision-making to choose and complete STEM pathways. Decisions these students make include choosing which institutions to attend, which majors and credentials to pursue, and which careers to undertake when moving into the labor market. Better understanding these decisions can help community colleges design STEM pathways that focus on student success.

This brief has also offered empirically grounded insights into how key elements of STEM pathways in community colleges work most effectively. This research points to the importance of supporting the diversity of post-traditional students who predominate community college STEM education. By supporting critical aspects of the student journey through a STEM pathways, such as associate degree completion, vertical transfer, baccalaureate attainment, and career preparation and employment, community colleges can play a critical role in meeting the students' needs in STEM education.

Four recommendations for community colleges seeking to improve STEM pathways and student decision-making follow.

1) **Reach consensus on the approach to STEM pathways that your community college seeks to implement.** Create a clear and consistent definition of STEM pathways that is widely disseminated and utilized within your community college, ensuring faculty, students and staff are well-informed of the plan. Also share this STEM pathway approach with partners and stakeholders, such universities and employers, who need to understand your community college's vision of student success in STEM education.

2) **Pursue STEM pathway designs that match your community college's goals to enhance high-quality STEM education.** For example, if your community college's goal is to improve transfer pathways in STEM, ensure that key elements of your community college's plan aligns with evidence-based STEM transfer pathway designs, including STEM course credit and credential completion.

3) **Map your community college's STEM pathway design against known pivotal points in student decision-making.** This requires understanding how diverse student populations, including post-traditional students, participate in and benefit from STEM education. Understanding how students make decisions that affect their learning experiences and outcomes is necessary to designing and delivering on effective STEM pathways in the community college.

4) **Conduct applied research and evaluation of your community college's STEM pathways**, including measuring student access, participation, retention, and completion, as well as tracking students into employment. The National Science Foundation (NSF) S-STEM scholarship grant requires external evaluation, which creates a valuable opportunity to gain deeper and more meaningful understanding of how students are benefiting from STEM pathways in community colleges. Ensuring your community college is conducting systematic evaluation that is producing meaningful results is important to your STEM students and may add to literature showing how to improve STEM education in community colleges nationwide.

## About the Author

**Debra D. Bragg** is President of Bragg & Associates Inc., a partner in the CCSN whose primary contributions include research and development, dissemination, and network building.

## Acknowledgements

Special thanks goes to Michelle Van Noy, Melissa Quaal, Annette Parker, Elizabeth Meza, Maria Espino, and Angel Butts for their contributions to the review, editing and formatting of this CCSN publication.

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This material is based upon work that is supported by the National Science Foundation under Grant Nos. DUE 2224623 and DUE 2224671. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.