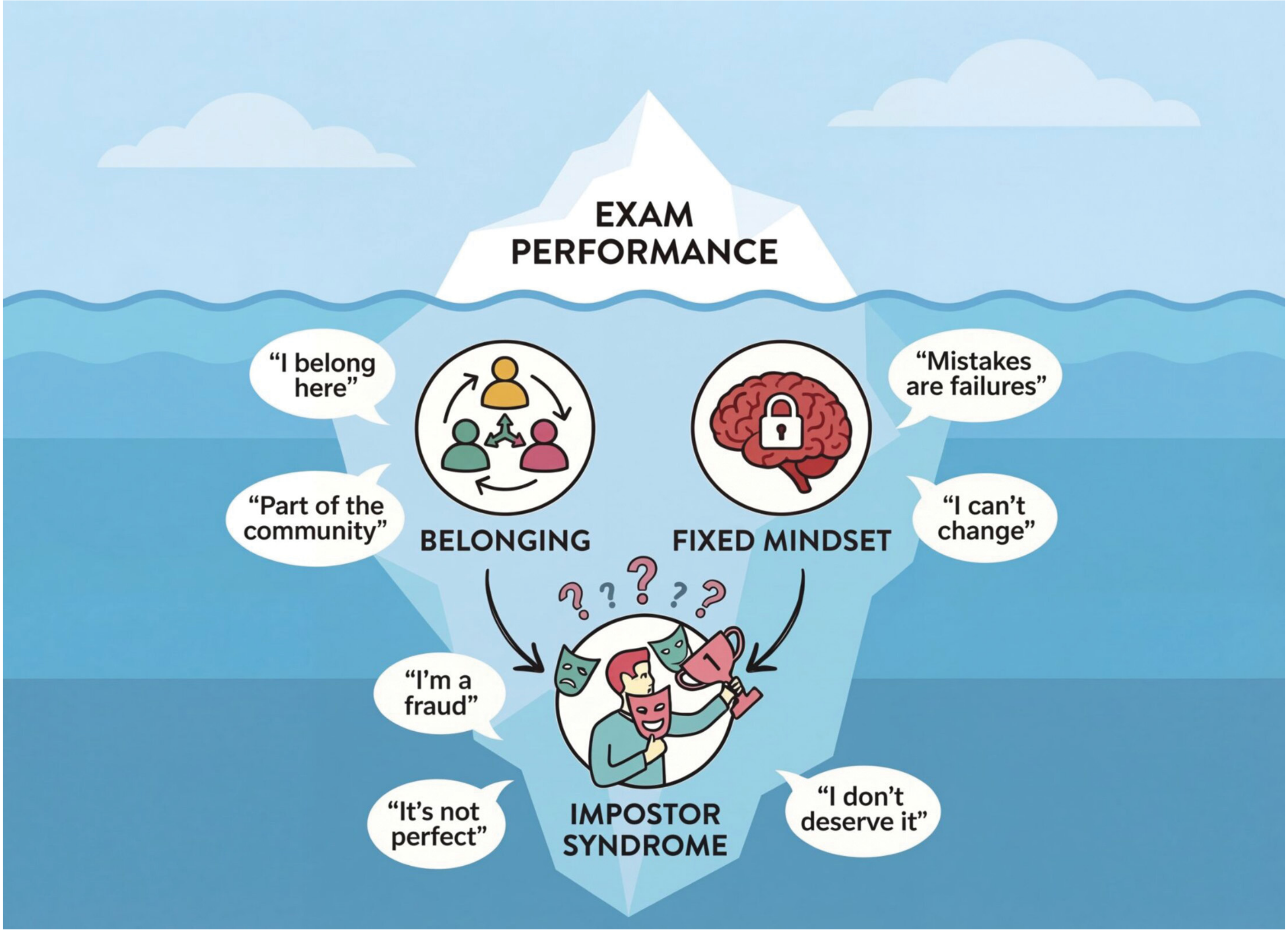

Showcasing research from Professor Regina F. Frey's laboratory, Department of Chemistry, University of Utah, Salt Lake City, Utah, United States.

Beyond content knowledge: affective factors continue to influence performance in organic chemistry II

This SEM path-analysis study examined how academic mindset, belonging, and imposter syndrome relate to Organic Chemistry II performance. Achievement was predicted by imposter syndrome (directly), belonging (indirectly), and mindset (directly and indirectly), highlighting the need for sustained attention to affective challenges.

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Beyond content knowledge: affective factors continue to influence performance in organic chemistry II

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This study examined how three affective variables (academic mindset entity beliefs, impostor syndrome, and sense of belonging) interrelate and influence performance in Organic Chemistry II, a second-year STEM course. Data were collected from students at a large, public, research-intensive university (N = 201), with performance measured by midterm average and a cumulative final exam score, controlling for prior knowledge from Organic Chemistry I. Structural equation modeling with path analysis was used to evaluate direct and mediated pathways among affective variables and performance. Results indicated that impostor syndrome and academic mindset directly predicted exam performance, while belonging exerted an indirect effect through impostor syndrome. Parallel mediation analyses further showed that academic mindset influenced achievement through two distinct pathways: impostor syndrome and prior knowledge. Students endorsing stronger fixed-ability beliefs reported higher impostor scores and lower prior knowledge, both negatively associated with exam scores. These results underscore that affective factors operate through interconnected cognitive and emotional mechanisms and persist beyond first-year coursework. Even after multiple semesters of college-level science, students entered Organic Chemistry II with self-doubt, fixed beliefs, or lower belonging, which are characteristics that undermine success. The persistence of these challenges into Organic Chemistry II highlights the need for sustained attention to affective dimensions in STEM education. Instructional strategies that normalize challenge, promote growth-oriented beliefs, and foster inclusive classroom communities are essential for reducing impostor-related barriers and supporting persistence. Addressing these affective factors alongside conceptual learning is critical for improving achievement and persistence in STEM.

Introduction

Lower-level chemistry courses, such as general and organic chemistry, typically serve as early prerequisites for students pursuing degrees in STEM and healthcare. Organic chemistry, in particular, is known to be a significant challenge for many students, with high withdrawal and failure rates (Grove *et al.*, 2008). Much of this difficulty arises from its abstract, mechanism-heavy content, which requires strong spatial reasoning and conceptual integration, creating novel challenges at this point in students' academic careers (Villafane *et al.*, 2016; Austin *et al.*, 2018). Success in these challenging lower-level chemistry courses is shaped by many factors, including academic preparation (Tai *et al.*, 2005; Micari *et al.*, 2016), socioeconomic disparities (Aikens and Barbarin, 2008; Brown *et al.*, 2016; Doerschuk *et al.*, 2016), and both cognitive and affective influences (Cromley *et al.*, 2016; Han *et al.*, 2017; Austin *et al.*, 2018; Hilts *et al.*, 2018; Edwards *et al.*, 2022a; Hedge, 2024; Bustamante and Frey, 2026; Laguerre Van Sickle and Frey, 2025). Prior research on cognitive influences has shown that mathematical ability (Lewis and Lewis, 2007; Korpershoek *et al.*, 2015; Willis *et al.*, 2022), prior conceptual knowledge (Seery, 2009; Xu *et al.*, 2013), study strategies (Rowell *et al.*, 2021; Walck-Shannon *et al.*, 2021; Laguerre Van Sickle and Frey, 2025), and scientific reasoning (Thompson *et al.*, 2018) all contribute to student performance.

Affective factors have been receiving increasing attention in STEM education; however, their impact on student performance remains unclear. Constructs such as sense of belonging, impostorism, and mindset have been associated with achievement and persistence (Fink *et al.*, 2018, 2020; Edwards *et al.*, 2022a; Bustamante and Frey, 2026), yet less understood is whether these affective constructs directly or indirectly affect student performance and how they relate to each other. A recent study by Bustamante and Frey (2026) found meaningful relationships among childhood science resources, academic

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mindset, belonging, impostor feelings, and performance in General Chemistry 1, which is the first college-level science course for many students. However, research on such relationships in organic chemistry, a course typically taken after students had success in general chemistry and other foundational sciences, remain more limited. These gaps highlight the need to better understand how affective constructs shape learning and persistence in introductory STEM courses, particularly in organic chemistry.

Previous studies on student performance and persistence in STEM disciplines have identified several affective influences, including social belonging, academic mindset, and imposter syndrome, that broadly shape students' academic experiences (Choi, 2005; Fink *et al.*, 2018, 2020; Moreno *et al.*, 2021; Edwards *et al.*, 2022a; Demirdöğen and Lewis, 2023; Bustamante and Frey, 2026). Building on this prior research, the present study explores how sense of belonging, a fixed academic mindset, and imposter feelings interact to influence performance in an Organic Chemistry II course. This analysis offers further insight into how affective factors function within rigorous courses that often shape students' continued engagement in STEM pathways.

Background

Affective constructs such as social belonging, impostorism, and academic mindset have each been examined individually within STEM learning environments, but their study varies substantially by course context. In general chemistry, social belonging has been investigated in several studies (Fink *et al.*, 2020; Edwards *et al.*, 2022a; 2023), and academic mindset has likewise been examined (Fink *et al.*, 2018). In contrast, research of these variables in organic chemistry has focused primarily on academic mindset (Limeri *et al.*, 2020), with no published studies to date examining social belonging in this context. Studies of impostorism have primarily centered on STEM professionals, such as faculty, graduate students, and medical trainees, as well as one large, multi-institutional sample spanning multiple STEM courses (Canning *et al.*, 2020), but not specifically within general chemistry or organic chemistry courses. Collectively, these prior studies illuminate the importance of ''unseen'' affective factors in shaping students' academic experiences and outcomes. However, only recently have these three constructs been examined together, and this work has been limited to General Chemistry I (Bustamante and Frey, 2026). To our knowledge, no studies have investigated how these constructs operate in combination within an organic chemistry course. Addressing this gap, the present study examines how these affective variables interact collectively, rather than in isolation, and how these interactions relate to academic performance in an Organic Chemistry II course taken four semesters into the undergraduate science sequence. Each construct is described in detail in the sections that follow.

Social belonging

Psychologist Abraham Maslow identified belonging as a fundamental human need, ranking it above the pursuit of knowledge and understanding in his hierarchy of needs (Maslow, 1962). Early models of belonging within higher education emphasized how student persistence depends on both social and academic integration into the campus community, which in turn fosters engagement and involvement (Tinto, 1975; 1993; Naylor *et al.*, 2018). Within educational contexts, a sense of belonging has been linked to student persistence and achievement. Research in STEM education has further demonstrated that students who report lower levels of belonging in science courses (*e.g.*, chemistry, physics, and biology) are less likely to remain in STEM fields (Hazari *et al.*, 2017; Rainey *et al.*, 2018; Fink *et al.*, 2020; Edwards *et al.*, 2023; Hansen *et al.*, 2023).

Social belonging in a course is defined by two components: sense of belonging and belonging uncertainty (Walton and Cohen, 2007; Edwards *et al.*, 2022a). Sense of belonging reflects the extent to which students feel accepted, valued, included, and supported by instructors and peers; in essence, whether they feel they ''belong'' in the course (Edwards *et al.*, 2022a; Hansen *et al.*, 2023). Belonging uncertainty, by contrast, captures students' doubts about whether people like them are welcomed or expected in the course environment: ''Do people like me belong here?'' where "people like me" may refer to a demographic group (*e.g.*, gender, race/ethnicity, first-generation status, rural or socioeconomic background) or to perceived academic capability (Cohen and Garcia, 2008). Prior research has linked students' social belonging to their performance in STEM courses (Gopalan and Brady, 2020; Chen *et al.*, 2021; Edwards *et al.*, 2022a; 2022b; Gehringer *et al.*, 2022; Jackson *et al.*, 2023; Brown *et al.*, 2024; Fong *et al.*, 2025), underscoring its importance as an affective construct. While belonging is a meaningful factor on its own, it is also important to consider its connections to other affective dimensions, since students often experience multiple affective influences simultaneously, and to examine its broader relationship to students' academic outcomes.

Imposter syndrome

The terms impostor syndrome (IS) and impostor phenomenon (IP) are often used interchangeably in the literature. Clance and Imes (1978) first described impostorism as a recurring sense of inadequacy and fear of being exposed as a fraud despite clear evidence of competence. They noted that individuals experiencing these feelings frequently try to compensate by working excessively hard, which can lead to high performance and reinforcement from authority figures. Subsequent research broadened the definition to include discomfort with success, attributing achievements to external factors, and denial of one's abilities (Clance, 1985; Harvey and Katz, 1985). Clance and Imes also emphasized that this pattern of overwork often serves as a means for avoiding the emotional discomfort associated with impostor feelings (Clance and Imes, 1978). Leary and colleagues (2000) later proposed distinguishing between ''true impostors,'' who believe others overestimate their competence, and ''strategic impostors,'' who downplay their abilities for interpersonal or self-presentational reasons. Although their findings did not fully support this proposed distinction, their study suggested that some impostor-like behaviors may be strategic rather than purely internal. In this view, individuals may genuinely experience impostor feelings, yet some behaviors associated with the phenomenon may reflect deliberate attempts to manage expectations or preempt negative evaluation.

Impostorism has been documented across a wide range of populations. In a longitudinal study of undergraduate STEM courses, Canning and colleagues found that perceived classroom competition was linked to higher daily in-class impostor feelings for all students, with particularly pronounced effects among first-generation students (Canning *et al.*, 2020). Their findings also showed that these impostor feelings predicted several important outcomes, including end-of-term engagement, attendance, intentions to withdraw, and course grades (Canning *et al.*, 2020). Other studies have found that impostorism disproportionately affects women (Clance and Imes, 1978; McGregor *et al.*, 2008; Tao and Gloria, 2019; Vaughn *et al.*, 2020), underscoring its uneven impact across student groups. Collectively, prior findings highlight the complexity of impostor experiences and raise important questions about how other affective factors may contribute to or amplify these feelings. For example, research with students of color, women, and first-generation college students has shown that impostor feelings can undermine a sense of belonging (Pulliam and Gonzalez, 2018; Stone *et al.*, 2018; Trefts, 2019; Collins *et al.*, 2020; Vaughn *et al.*, 2020). However, much of this work has focused on STEM professionals, including faculty (Clance and Imes, 1978; Chakraverty, 2022), graduate students (Hutchins, 2015), and medical trainees (Gottlieb *et al.*, 2020). Recent work in general chemistry identified impostor syndrome as a key predictor of performance and a mediator for other affective constructs, demonstrating its relevance early in the STEM undergraduate sequence (Bustamante and Frey, 2026). Whether this influence persists after successful completion of three semesters of lower-level chemistry courses remains unknown. Thus, further research is needed to investigate impostorism among undergraduate STEM students, especially in lower-level courses such as organic chemistry.

Academic mindset

Mindset theory, often referred to as implicit theories of intelligence, proposes that individuals hold either a fixed (entity) mindset or a growth (incremental) mindset about intelligence (Dweck, 2008). In academic contexts, students with a fixed mindset tend to view intelligence as stable and unchangeable, interpreting setbacks as reflections of their inherent ability, whereas students with a growth mindset believe intelligence can be developed and that mistakes or failures offer opportunities for learning and improvement (Dweck, 2008). Research has consistently shown that these beliefs are linked to important differences in students' academic achievement (Dweck, 1999; Robins and Pals, 2002; Blackwell *et al.*, 2007; Fink *et al.*, 2018, 2023a). However, endorsing a growth mindset about intelligence in general does not necessarily mean that students feel confident in their personal capacity to improve. De Castella and Byrne (2015) found that adolescents' perceptions of their *own* intelligence, rather than beliefs about intelligence more broadly, were stronger predictors of motivation, engagement, and performance, highlighting the nuanced nature of mindset as an affective construct and underscoring the importance of students' self-perceptions in shaping academic outcomes.

Research indicates that students who endorse a growth mindset tend to achieve at higher levels than those who hold fixed views of intelligence, showing greater persistence, resilience, and success in their learning (Dweck and Molden, 2000; Blackwell *et al.*, 2007; Dweck, 2008; Yeager and Dweck, 2012; Limeri *et al.*, 2023; Chouvalova *et al.*, 2026). A 2020 study of organic chemistry students by Limeri and colleagues reported that students with a more fixed mindset tended to earn lower grades and were more likely to leave their field, whereas those with a growth mindset earned higher grades and were more likely to persist (Limeri *et al.*, 2020). Additionally, in a study of 643 Australian high school students aged 15 to 19, De Castella and Byrne (2015) found that fixed mindset beliefs were associated with lower endorsement of achievement goals, stronger helplessness attributions, and poorer self-reported academic performance. These beliefs also predicted academic self-handicapping, truancy, and disengagement. In response to such findings, growth mindset interventions were developed to counter fixed beliefs by teaching students about the malleability of intelligence and fostering greater willingness to take on academic challenges. Evidence from recent work demonstrates that well-designed mindset interventions can raise course grades and promote persistence in STEM fields (Yeager and Walton, 2011; Fink *et al.*, 2018, 2023a; Yeager *et al.*, 2019).

Although much of the mindset literature focuses on students, research has shown that instructors' mindsets play an important role in shaping learning environments (Canning *et al.*, 2019; Muenks *et al.*, 2020; LaCosse *et al.*, 2021; Kroeper *et al.*, 2022). Studies by Canning and O'Leary and their colleagues highlight how instructors' beliefs about intelligence influence the classroom climate and the support students perceive exists (Canning *et al.*, 2019; O'Leary *et al.*, 2020). Additionally, in a structural equation modeling (SEM) analysis, Kattoum and colleagues found that students who perceived their instructor as holding a fixed mindset reported a stronger sense of academic misfit, which subsequently predicted lower chemistry grades (Kattoum *et al.*, 2024). Together, these findings emphasize the broader role of mindset in shaping students' academic experiences and outcomes, and point to the need for continued attention to the factors that influence students' mindset beliefs.

Affective constructs and their effect on course exam performance

Prior literature has shown that students' social belonging predicts exam performance in General Chemistry I (Fink *et al.*, 2020; Edwards *et al.*, 2022a) and introductory physics (Edwards *et al.*, 2022b), supporting its inclusion in the present analysis. In a longitudinal study of 818 STEM students, Canning *et al.* (2020) found that classroom competition predicted stronger impostor feelings, which were associated with lower grades, reduced engagement, poorer attendance, and higher intentions to withdraw. Similarly, academic mindset has been connected to course performance, persistence, and belonging

(Limeri *et al.*, 2023), although empirical findings are mixed. For example, Cavanagh *et al.* (2018) found that trust in the instructor, rather than mindset, predicted final grades, while Kattoum and Baillie (2025) observed age-related differences in the effects of mindset interventions. Nevertheless, several studies have shown that growth mindset interventions can enhance academic achievement in both college STEM courses (Fink *et al.*, 2018, 2023a) and K-12 settings (Hwang *et al.*, 2019). To extend this work to the context of Organic Chemistry II, the present study uses SEM path analysis to examine whether beginning-of-semester affective measures (sense of belonging, impostor feelings, and entity mindset) predict performance on the average of the midterm exams and on the final exam, after accounting for prior content knowledge. Including both assessments allows us to evaluate the influence of these constructs at two different time points in the course.

Structural equation modeling (SEM) path analysis

Structural equation modeling (SEM) is a versatile statistical method for evaluating theoretically motivated and complex relationships among multiple constructs, including both measured and latent constructs (Hoyle, 2012; Chen and Yung, 2024). A major advantage of SEM is its ability to evaluate both direct and indirect pathways, making it particularly valuable for testing theoretical models that suggest mediating or moderating processes (Hancock and Mueller, 2013). As such, SEM is well suited to questions in which multiple psychosocial or affective constructs may operate in concert to influence academic outcomes.

Path analysis is a related but more specialized technique that focuses on observed variables. It extends the multiple regression method by employing path diagrams to depict hypothesized causal relationships among observed variables and estimating the magnitude and significance of these proposed relationships (Streiner, 2005). Importantly, path analysis does not, by itself, establish causality or guarantee that the specified model is uniquely correct. Instead, it assesses whether the observed data are consistent with the hypothesized pattern of relations (Streiner, 2005; Byrne, 2013). When research questions concern the interplay among measured constructs (*e.g.*, affective factors and performance) and the decomposition of effects into direct and indirect components, path analysis offers a transparent and interpretable starting point.

When combined, SEM builds upon path analysis by incorporating latent variables, which are unobservable constructs that are inferred from multiple measured indicators; this allows researchers to reduce measurement error and evaluate more sophisticated models (Hoyle, 2012). SEM further allows for parameter constraints, mediation testing, multi-group comparisons, and hierarchical models, offering a versatile framework for addressing complex theoretical questions. When SEM and path analysis are integrated, they provide a comprehensive analytic strategy for examining both simple and intricate relationships in multivariate data (Chavance *et al.*, 2010). Model development and evaluation generally proceed in three stages (Byrne, 2013): (1) formulating a theoretical model grounded in prior research, (2) assessing how well the model fits the observed data through goodness-of-fit indices, and (3) evaluating the statistical significance and contribution of specific model parameters (Hancock and Mueller, 2013; Kline, 2016). In the present work, this SEM/path-analytic perspective is applied to examine how multiple affective variables operate jointly in relation to performance.

Hypothesized relationships between affective constructs

Prior research has proposed several relationships among the affective constructs examined in this study. For example, findings from Bustamante and Frey's SEM path analysis for General Chemistry 1 found that, using early-semester variables, higher fixed academic mindset and stronger imposter syndrome each directly predicted lower exam performance (*i.e.*, negative effects on performance), demonstrating how these constructs can jointly shape students' academic outcomes (Bustamante and Frey, 2026). Additional studies have identified connections among these affective constructs. Kenneally *et al.* reported a positive association between fixed-mindset and imposter syndrome in pharmacy students (Kenneally *et al.*, 2023), and Noskeau and colleagues found that adults with stronger fixed mindset beliefs were more likely to experience impostorism, a relationship largely explained by fear of failure (Noskeau *et al.*, 2021). These patterns informed our hypothesis that students' academic mindset would predict their impostor feelings. Literature linking belonging and impostorism further supports examining these constructs together; however, prior research suggests multiple plausible directional relationships. For instance, a study of first-year college students showed that higher social and academic belonging were associated with lower impostor feelings across the first six months of college (Dao *et al.*, 2024), implying that belonging may shape impostor experiences. In contrast, recent work in general chemistry found that stronger impostor feelings predicted a lower sense of belonging, suggesting the reverse directionality (Bustamante and Frey, 2026). Because these relationships have not been examined in Organic Chemistry II, we tested both directional pathways to better understand how belonging and impostor feelings relate within this course context. Together, these findings highlight the importance of examining directional relationships among belonging, impostor feelings, and mindset in Organic Chemistry II.

Research question (RQs)

Although belonging, impostorism, and mindset have been shown to each independently influence student performance, students often experience these affective factors simultaneously. This study examines how early-semester levels of these constructs relate to one another and how they affect exam performance throughout the semester. To our knowledge, these relationships were first studied together only recently in General Chemistry I (Bustamante and Frey, 2026), which students often take as one of their first college-level science courses. However, the ways in which these constructs interact to influence student performance have yet to be examined in organic chemistry, which students typically take only after being successful in the general chemistry series. Using structural equation modeling (SEM) path analysis, we tested models to address the following research questions:

1. To what extent do these three early-semester affective measures (sense of belonging, imposter syndrome, and academic mindset entity) affect the average midterm exam and final exam performances in Organic Chemistry II (OC2)?

2. What are the relationships between sense of belonging, imposter syndrome, and academic mindset entity at the beginning of the semester?

Methods

Study setting

This research was conducted during the Spring 2023 semester at a large public research-intensive university in the Mountain West region of the United States, which enrolls roughly 30 000 undergraduates. Data collection focused on the lecture component of Organic Chemistry II (OC2), the second course in a two-semester sequence required for many science, engineering, and pre-health majors. The course section examined in this study enrolled approximately 250 students and was designed to help students develop skills in predicting the stability and reactivity of functional groups, designing multi-step syntheses, analyzing molecular structures using mass spectrometry, infrared spectroscopy, and nuclear magnetic resonance spectroscopy, and understanding the reactivity of biologically relevant molecules. The associated laboratory is a separate course and was not included in this study.

The OC2 course met in-person three times per week for 50-minute lectures and once per week for a 50-minute Discussion section. Discussions were facilitated by 38 undergraduate teaching assistants (TAs) and learning assistants (LAs); the undergraduate LAs are trained in facilitating collaborative, active-learning activities (Barrasso and Spilios, 2021). Students worked in small groups to solve instructor-prepared worksheet problems, with credit awarded for punctuality, participation, and demonstrated effort, as judged by the TAs and LAs. The course was taught by a single instructor who also held two weekly office hours and offered additional 15-minute appointments by request.

Course grades were determined primarily by four exams, consisting of three one-hour midterms (administered on February 11, March 18, and April 15) and a cumulative final (held during finals week), which together comprised 66% of the total grade (15% each midterm, 22% final). All exams were administered on paper and in person. Additional graded components included in-class quizzes (6%), discussion worksheets and surveys (7%), in-class Poll Everywhere responses (6%), and post-discussion quizzes (15%).

Participants

Study participants were recruited from OC2 during the Spring 2023 semester. Among the 227 enrolled students, 201 consented to participate, completed the beginning-of-semester survey, and had available OC1 final exam scores (used as a measure of prior content knowledge); this group formed the *total* dataset, which included students who may not have completed the end-of-semester survey or finished the course. Of these 201 students, 183 also completed the end-of-semester survey; this group formed the *matched* dataset (*i.e.*, students who completed both surveys and finished the course). All SEM path analyses were conducted using the matched dataset (N = 183) to reflect students who completed the course. Of those 183, 39% were second-year students, 37% were third-year students, 16% were fourth-year students, and 8% were classified as other/prefer not to answer. All recruitment and study procedures were approved by the university's Institutional Review Board (IRB_00145042). Students received course credit for completing the surveys, independent of their consent to allow their data to be used for research; no compensation was given for research participation.

Demographics

Students' self-reported demographic information was obtained from the Early Semester (ES) survey, focusing on three variables: gender, first-generation status, and race or ethnicity. In response to the question, "To which gender identity do you most identify?" students selected from options: "Woman" (N = 101), "Man" (N = 76), "Non-binary" (N = 0), "Prefer to self-describe" (N = 4), and "Prefer not to answer" (N = 2). To determine first-generation status, students were asked, "Did any of your parents/legal guardians obtain a college degree?" with responses including "Yes" (N = 154), "No" (N = 26), or "I do not know/prefer not to answer" (N = 3). In response to the question, "I identify my race/ethnicity as: [Select all that apply]," students indicated their identity with options: "Asian" (N = 21), "Black/African American" (N = 2), "Hispanic/Latinx" (N = 14), "Native American/Alaskan Native" (N = 0), "Pacific Islander" (N = 1), "White" (N = 119), "Prefer to self-describe" (N = 0), "Prefer not to answer" (N = 5), with 21 students selecting more than one race. We recognize the limitations of the term "Asian," as students under this category may come from diverse cultural and ethnic backgrounds, leading to substantially different experiences in STEM (McGee *et al.*, 2017; Chen and Buell, 2018). However, demographic variables were not included in the statistical analyses in the current study; instead, all students were analyzed as a single group.

Academic preparation

The Organic Chemistry II preparation was measured using students' raw cumulative final exam scores from Organic Chemistry I (OC1), which were obtained from multiple OC1 course sections. Because grading patterns and exam difficulty can vary across sections, scores were z-scored within section (average = 110.19 $\pm$ 27.51 out of 150 possible points) to place all students on a common scale and ensure comparability of academic preparation across the OC1 cohorts. Although various OC2 pre-assessments have been piloted in prior semesters at this institution, instructors permitted students to study for these assessments, making them unsatisfactory measures of students' pre-knowledge entering the course. Additionally, ACT scores were not included as a measure of preparation, as the institution no longer requires ACT submission for admission, resulting in incomplete data for many students. Thus, the OC1 final exam was selected as the most consistent and reliable indicator of students' prior Organic Chemistry II preparation.

Measures

Social belonging. Students' social belonging was assessed using a six-item instrument adapted by Fink and colleagues (2020) from earlier psychology research (Walton and Cohen, 2007). The items were rated on a 6-point Likert scale ranging from 1 (''Strongly Disagree'') to 6 (''Strongly Agree''). The measure captures two distinct factors: sense of belonging and belonging uncertainty. The four sense-of-belonging items gauge students' perceptions of connection and fit within the specific lecture course (*e.g.*, *''I feel like I fit in [course name]''*). The two belonging-uncertainty items reflect the degree to which students feel that their belonging is unstable or dependent on performance (*e.g.*, ''I feel uncertain about my belonging in [course name]''), meaning that feelings of belonging can fluctuate. To ensure students considered only the lecture course, the survey wording referred to the actual lecture course title rather than to a general organic course.

Since this specific social belonging instrument has been used in chemistry courses at the same institution (Edwards *et al.*, 2022a; 2023; Bustamante and Frey, 2026), we confirmed the internal structure of the two-factor model using confirmatory factor analysis (CFA). Additionally, because we incorporated individual factors, such as Sense of Belonging, into the SEM path analyses, we conducted separate unidimensional CFAs for each factor. Because the Belonging Uncertainty construct was measured with only two items, its internal structure could not be meaningfully evaluated using CFA, whereas Sense of Belonging demonstrated a suitable fit for a unidimensional model. Therefore, the SEM path analyses used only 'Sense of Belonging.' Please see the Results Section for the CFA results for the original two-factor structure (Sense of Belonging and Belonging Uncertainty) and the CFA results for the unidimensional Sense of Belonging factor. The SI contains the survey and more details of the CFAs.

Imposter syndrome. Impostor syndrome was measured using a four-item scale adapted by Canning and colleagues (2020) from the Leary Impostorism Scale (Leary *et al.*, 2000). The original seven-item instrument was designed to assess feelings of impostorism, such as fraudulence, fear of being discovered, and difficulty internalizing success. In the adapted version, students responded to the prompt, *''Please indicate the extent to which you agree with each of the following statements as a student of [course name],''* using a 6-point Likert scale ranging from 1 (''Strongly Disagree'') to 6 (''Strongly Agree''). One example item is: *''In class, I feel like people might discover that I am not as capable as they think I am.''* Although this scale has been previously implemented at our institution (Bustamante and Frey, 2026), its broader use is limited. Therefore, in this study, we first examined the internal structure of the measure using exploratory factor analysis (EFA), followed by confirmatory factor analysis (CFA) to confirm the resulting factor structure. Because the Imposter Syndrome construct is a unidimensional model, no additional CFA was required prior to its inclusion in SEM path analysis. For survey questions and in-depth EFA and CFA results, please see the SI.

Academic mindset. Students' academic mindset was measured using an adaptation of the revised Implicit Theories of Intelligence Scale (ITIS; Self-Theory) developed by De Castella and Byrne (2015). The survey was administered on a 6-point Likert scale ranging from 1 (''Strongly Agree'') to 6 (''Strongly Disagree''). The original ITIS (Self-Theory) consists of four *entity* items (*e.g.*, *''I don't think I personally can do much to increase my intelligence''*) and four *incremental* items (*e.g.*, *''With enough time and effort, I think I could significantly improve my intelligence level''*). For the current study, these statements were modified to have students focus on ''chemistry intelligence''. For example, an entity item was rephrased as *''I don't think I personally can do much to increase my chemistry intelligence,''* while an incremental item was adapted to *''With enough time and effort, I think I could significantly improve my chemistry intelligence level.''*

In this study, the internal structure of the measure was first evaluated using exploratory factor analysis (EFA), followed by confirmatory factor analysis (CFA) to confirm the identified two-factor structure. To incorporate the use of a total score from each individual factor, such as Entity, into the SEM path analyses, we conducted separate unidimensional CFAs for each factor. For the adapted survey questions, EFA, and CFA results of the two-factor structure (incremental and entity), as well as the unidimensional entity CFA, please see the SI.

Data collection

Study data were gathered using the Qualtrics online survey platform (Qualtrics, 2020). The survey was administered twice over the course of the semester, with credit awarded for thoughtful completion. Following IRB-required study introduction, which included a brief in-class presentation and detailed course emails, the first administration opened at the end of the first week of the semester and remained open for one week, capturing baseline measures of academic mindset, impostor syndrome, and social belonging prior to substantial exposure to the course or any performance feedback. The second administration was during the final week of the semester, just prior to the final exam period. Responses from the first survey are referred to as *early semester (ES)* data, while responses from the second survey are labeled *late semester (LS)* data. At the conclusion of the course, instructors provided assignment, participation, and exam grades for consenting students, which were then matched to the corresponding survey records.

Data analysis

All statistical analyses were conducted in RStudio (version 2025.05.0 + 496) using a suite of specialized packages, including *lavaan* (0.6 series; Rosseel, 2012), *psych* (2.4.6.26; Revelle, 2017), *dplyr* (1.1.4; Wickham *et al.*, 2023), *MBESS* (version 4.9.41) (Kelley, 2007), *manymome* (Cheung and Cheung, 2024), *polycor* (0.8–1; Fox and Dusa, 2022), *fungible* (2.4.4; Waller, 2016), *semTools* (0.5–7; Jorgensen *et al.*, 2016), and *FactorAssumptions* (2.0.1; Storopoli, 2022).

Exploratory factor analysis (EFA). EFA is a multivariate statistical approach used to identify the latent structure underlying a set of observed variables (items) by revealing shared dimensions or common factors (Beaujean, 2014; Hair *et al.*, 2019). This data-driven method does not impose prior assumptions regarding the number or pattern of factors; instead, latent variables are extracted empirically from the dataset based on inter-item relationships.

Confirmatory factor analysis (CFA). CFA is a hypothesis-driven technique employed to evaluate how well observed variables represent their underlying latent constructs (factors). It requires specifying a theoretical measurement model, estimating the implied covariance matrix, and comparing it to the observed covariance matrix to assess model fit. Model fit is assessed using standard indices as suggested by Hu and Bentler (1999). This includes: the Comparative Fit Index (CFI), which should be ≥ 0.95 (Yuan *et al.*, 2016); the Tucker-Lewis Index (TLI), which should be ≥ 0.95 (Watkins, 2021); the Root Mean Square Error of Approximation (RMSEA), which should be less than 0.06 (Browne and Cudeck, 1993); and the Standardized Root Mean Square Residual (SRMR), which should be less than 0.08 (Hu and Bentler, 1999). Model fit thresholds were evaluated using criteria established by Hu and Bentler and by Yuan and Marcoulides. Model fits were then described using the qualitative descriptors proposed by Yuan and Marcoulides, which assign a range of adjectives to specific values of RMSEA (0.01 = "excellent," 0.05 = "close," 0.08 = "fair," and 0.10 = "poor") and CFI (0.99 = "excellent," 0.95 = "close," 0.92 = "fair," and 0.90 = "poor") (Yuan *et al.*, 2016). It is important to note that these cutoffs function as flexible guidelines, not strict rules, and should be considered alongside additional evidence when evaluating model fit (Goretzko *et al.*, 2024).

Analytic procedure. To support the internal consistency of the data from the measures in our sample population, we conducted comprehensive data screening and factor analyses. Measures of social belonging, imposter syndrome, and academic mindset were collected at both the beginning and end of the semester. For the Impostor Syndrome (pre_IS) scale, since the factor structure has not been previously determined in a similar population, the total dataset ($N = 201$), which contained the consented students who completed the beginning-of-semester survey, was randomly divided into two subsets: one for exploratory factor analysis (EFA; DS1 (training set), $N = 100$) and the other for confirmatory factor analysis (CFA; DS2 (testing set), $N = 101$). This split-sample approach was used to establish and provide evidence for the factor structure for this measure. For academic mindset, the factor structure has been determined in prior literature as well as in the General Chemistry 1 course at this institution. However, since the self-theory survey has not been widely used at this institution or in chemistry, to give more evidence in the literature about the survey's factor structure, we performed an EFA on our Organic Chemistry II sample. The EFA followed by CFA was conducted for this construct using the matched dataset ($N = 183$) to evaluate its structure in the Organic Chemistry II context. Last, because the internal structure of the Belonging instrument has been consistently supported across multiple prior studies at our institution, only a CFA was performed for this construct using the matched dataset ($N = 183$).

Data normality and variability were assessed using descriptive statistics, including histograms, means, standard deviations, skewness, and kurtosis (please see SI for detailed results). Mardias test confirmed violations of multivariate normality across all measures. As a result, polychoric correlations were used for the EFAs, while ensuring that a substantial number of correlations exceeded 0.30, indicating sufficient intercorrelation among items to justify factor analysis (Watkins, 2018). To identify the appropriate number of factors to retain for rotation, two post-estimations were conducted: minimum average partial (MAP) (Velicer, 1976) and scree plots (please see SI for detailed results). Kaiser-Myer Olkin (KMO) and Barlett's tests indicated sampling adequacy (please see SI for test results for each respective measure). Due to non-normality, EFAs were performed using Polychoric correlations with Principle Axis Factoring (PAF) extraction and Promax oblique rotation, referencing standard cutoffs for factor loading and model fit. Multicollinearity was checked using VIFs, and no issues were identified. These analyses ensured that our model assumptions were met and that the latent structures were appropriate for the sample. Full procedural details are available in the SI.

SEM-path analysis

In the present study, SEM path analysis was used to test our theoretically informed model and to estimate the direct and indirect relationships among the measured constructs. After specifying the path model based on prior literature, we evaluated model adequacy using standard goodness-of-fit indices. These included the Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI), which assess relative fit compared with a baseline model; the Root Mean Square Error of Approximation (RMSEA), which evaluates approximate fit based on residuals; and the standardized root mean square residual (SRMR), which quantifies the discrepancy between observed and predicted correlations (Kline, 2010). We then conducted mediation analyses within the SEM framework using bias-corrected bootstrapping to obtain robust estimates of indirect effects. Bootstrapping is recommended for mediation testing because the sampling distribution of indirect effects is often non-normal, and bootstrapped confidence intervals provide more accurate inferential estimates than traditional methods. In the sections that follow, we elaborate on the bias-corrected bootstrapping procedure used to estimate indirect effects, as well as the mediation and parallel mediation models applied to evaluate the proposed pathways.

Bootstrapping. Bootstrapping is a procedure in which multiple new samples are generated from the original dataset by randomly selecting observations, allowing for the same observation to be chosen more than once (resampling with replacement). This process is repeated many times (*e.g.*, 7500 iterations) to produce robust confidence intervals and provide a more accurate assessment of effect significance within the SEM framework (Bollen and Stine, 1992; Sharma and Kim, 2013; Kattoum *et al.*, 2024). Bootstrapping is particularly advantageous in mediation models, where it is often used to obtain confidence intervals and standard errors for both direct and indirect effects. In the present study, we employed SEM with bootstrapping in a post-hoc manner to evaluate both direct and indirect effects using mediation.

Mediation analysis. Mediation analysis is a statistical approach used to evaluate the mechanism through which an independent variable (X) affects a dependent variable (Y), specifically by determining whether the effect operates indirectly through an intermediary variable, or mediator, (M). This process involves mapping the directional paths connecting X and Y, ensuring that each path follows the direction of the causal arrows (Hayes, 2018). A path from X to Y that includes M represents an indirect effect, whereas a path that connects X to Y directly, without M, represents a direct effect (Chen and Yung, 2024). Direct and indirect effects are derived from model coefficients, with indirect effects estimated by multiplying the relevant regression coefficients. Rather than relying solely on significance tests (*e.g.*, z- or p-values), it is recommended to report effect estimates alongside confidence intervals (CIs) to convey both the precision and practical significance of the results (Hancock *et al.*, 2018). Consequently, mediation analyses typically report four main statistics: the coefficient estimate (β), its standard error (S.E.), and the lower and upper bounds of the confidence interval (LLCI and ULCI).

In addition to simple mediation, the present study used parallel mediation analysis. Parallel mediation occurs when a single independent variable influences a dependent variable through two or more mediators that operate simultaneously and independently, rather than sequentially (Preacher and Hayes, 2008; Hayes, 2013). In this framework, each mediator represents a distinct pathway through which X may be associated with Y. Parallel mediation models estimate the direct effect of X on Y while controlling for all mediators, the specific indirect effect through each mediator, the total indirect effect (*i.e.*, the sum of all indirect paths), and the total effect (*i.e.*, the combined direct and indirect effects) (MacKinnon, 2008; Zhao *et al.*, 2010).

Parallel mediation is particularly appropriate when multiple, conceptually distinct mechanisms link an independent variable to an outcome (Hayes, 2013). Modeling mediators in parallel allows for the examination of their unique contributions while reducing the risk of omitted variable bias that can occur when mediators are tested in isolation (Preacher and Hayes, 2008; Zhao *et al.*, 2010). This approach also allows for comparison of the relative magnitude of indirect effects, estimating the relative contribution of each pathway. It is important to note that researchers should exercise care in how they describe mediation findings.

For all mediation analyses, Hancock *et al.* advise that terms such as ''causes,'' ''influences,'' or ''impacts'' be used only when working with longitudinal data (Hancock *et al.*, 2018). In contrast, others in the field generally permit causal wording in experimental designs (*e.g.*, X causes Z, which subsequently causes Y) (MacKinnon and Luecken, 2008; Hayes, 2009; Kenny and Judd, 2014).

Results

Exploratory factor analysis (EFA)

In this study, three affective constructs were analyzed: Sense of Belonging, Imposter Syndrome, and Academic Mindset–Entity. For the Imposter Syndrome (pre_IS) scale, since the factor structure has not been well studied in STEM populations, the full dataset (N = 201) was randomly divided into two subsets: one for exploratory factor analysis (EFA; DS1 (training set), N = 100) and the other for confirmatory factor analysis (CFA; DS2 (testing set), N = 101). This split-sample approach was used to establish and provide evidence for the factor structure for this measure. Since both the Academic Mindset-Entity and Sense of Belonging internal structures had been previously confirmed at this institution, CFAs were conducted using the matched dataset (N = 183).

Data normality and variability were examined using descriptive statistics, including means, standard deviations, skewness, kurtosis, and visual inspection of histograms. Mardia's test revealed violations of multivariate normality across all measures. Consequently, polychoric correlation matrices were used in the EFAs. A substantial proportion of inter-item correlations exceeded 0.30, indicating adequate interrelationships among variables to justify factor analysis (Watkins, 2018). Collectively, these analyses ensured that model assumptions were met and that the latent factor structures were well supported by the data. Full procedural details and detailed results are provided in the Methods section and the SI.

Multidimensional confirmatory factor analysis (CFA)

Multidimensional CFAs were performed using the maximum likelihood mean-adjusted (MLM) estimator for social belonging (SB) and academic mindset (AM). Given the presence of multivariate non-normality, model fit was evaluated using the Satorra–Bentler scaled chi-square test, which provides robust fit estimation under violations of normality (Satorra and Bentler, 1994).

For social belonging, the model demonstrated an *excellent* fit (CFI = 0.997, TLI = 0.994, RMSEA = 0.038, SRMR = 0.025). For academic mindset, CFA results indicated a *close* model fit, as evidenced by the fit indices: CFI = 0.989, TLI = 0.984, RMSEA = 0.070, and SRMR = 0.041. For both constructs, all indices met the recommended thresholds (Clark and Bowles, 2018).

CFAs were conducted to evaluate the measurement model and to provide reliability evidence based on the data, as CFAs require strong *a priori* hypotheses about the relationships between latent constructs (factors) and observed item responses, allowing explicit testing of the measurement structure (Flora, 2020). To assess the reliability of the data representing each multidimensional construct, McDonald's omega coefficients were calculated separately for each factor, since omega (ω) assumes unidimensionality of the items contributing to a given factor (Komperda *et al.*, 2018). Because the social belonging and academic mindset constructs each include distinct subdimensions, computing ω for each factor individually ensured that reliability estimates reflected variance specific to each latent construct. Commonly cited thresholds for omega are 0.70 (Streiner, 2005; Lance *et al.*, 2006; Watkins, 2017); however, others simply put that higher values are preferrable (Bandalos, 2018; Komperda *et al.*, 2018; Lewis, 2022). To quantify the precision of these reliability estimates, 95% bias-corrected and accelerated (BCa) bootstrap confidence intervals (CIs) were computed using the MBESS package in R (Kelley, 2007). These intervals were generated based on 1000 bootstrap resamples with BCa bias-corrected and accelerated (BCa) adjustment to provide robust interval estimates around the omega coefficients. Internal consistency reliability values were as follows: Social Belonging – Sense of Belonging $\omega = 0.89$ (95% C.I [0.884, 0.935]); Belonging Uncertainty $\omega = 0.75$ (95% C.I [0.644, 0.812]), and Academic Mindset – Entity $\omega = 0.95$ (95% C.I [0.926, 0.968]); incremental $\omega = 0.93$ (95% C.I [0.903, 0.945]). Complete CFA model results and associated fit statistics are provided in the SI.

Unidimensional confirmatory factor analysis (CFA)

To support the use of a total score for the specific factors for our path analysis, we conducted separate unidimensional CFAs for each construct in the models. This procedure confirmed that the items within each construct adequately loaded onto a single latent variable, thereby justifying their inclusion in subsequent SEM path analyses.

For the sense of belonging construct (SB; four items), the unidimensional CFA yielded a non-significant chi-square test, $\chi^2(6) = 1.898$, $p = 0.387$. Global fit indices also supported an *excellent* fit (CFI = 1.00, TLI = 1.00, RMSEA = 0.00, SRMR = 0.018). Although "perfect" model fit values warrant cautious interpretation, further diagnostics (including examination of modification indices and residuals) provided additional evidence of model adequacy, with no residuals exceeding 0.05 (Kim *et al.*, 2016; see SI for details). Standardized factor loadings were all statistically significant and exceeded recommended thresholds, ranging from 0.584 to 0.909. Model-based composite reliability (McDonald's omega) for the data from the sense of belonging measure was 0.84, indicating high internal consistency reliability in participants' responses. The decision to conduct these additional checks for the Sense of Belonging model stemmed from the appearance of "perfect" fit indices (CFI and TLI = 1.00; RMSEA = 0.00). While these three indices are conventionally used to assess fit, several scholars have emphasized the importance of a more comprehensive, multi-criterion approach to evaluating internal structure (Maydeu-Olivares and Shi, 2017; Shi *et al.*, 2019; Goretzko *et al.*, 2024).

The imposter syndrome (IS) construct, consistent with prior theoretical and empirical work, was modeled as a single-factor structure comprising four items. For the imposter syndrome (IS) construct, the CFA produced a non-significant chi-square statistic, $\chi^2 = 2.777$, $p = 0.249$. Overall, the model demonstrated a strong fit (CFI = 0.994, TLI = 0.983, SRMR = 0.023). Although RMSEA (0.086) slightly exceeded the conventional cutoff of 0.08, this value is often considered marginally acceptable in applied research (Hu and Bentler, 1999; Schermelleh-Engel *et al.*, 2003). Given the excellent incremental and residual fit, we will use this model in our path analyses. All standardized factor loadings were statistically significant and surpassed recommended thresholds, ranging from 0.740 to 0.972. Model-based composite reliability (McDonald's omega) for the data reflecting imposter syndrome was 0.87, indicating high internal consistency reliability in participants' responses.

For the Academic Mindset–Entity (AME) construct (four items), the unidimensional CFA yielded a non-significant chi-square test, $\chi^2 = 3.363$, $p = 0.186$. Global fit indices further supported a *close* model fit, with CFI = 0.997, TLI = 0.992, RMSEA = 0.076, and SRMR = 0.009. All standardized factor loadings were statistically significant and exceeded conventional cutoffs, ranging from 0.834 to 0.953. Model-based composite reliability (McDonald's omega) for the data from the academic mindset entity measure was 0.95, indicating high internal consistency reliability in the observed responses. Hence, we used these three constructs in our SEM path analyses.

SEM path analysis

Structural equation modeling (SEM) path analysis was employed to evaluate a series of path models representing networks of interrelated variables simultaneously. All analyses were conducted using the matched dataset ($N = 183$). Each model incorporated the three early-semester affective constructs of interest, and all proposed pathways were informed by prior literature (see Background section). Parameter estimates are reported as unstandardized path coefficients (β) along with p-values adjusted for multiple comparisons using the False Discovery Rate (FDR) correction method (Benjamini and Hochberg, 1995; Narum, 2006).

For each performance outcome (OC2 Avg Midterms and OC2 Final Exam), one model emerged as providing the best overall fit among those tested (see Methods section for model-fit criteria). As described in the Background section, we evaluated multiple directional pathways between Sense of Belonging and Impostor Syndrome. In contrast to prior work in General Chemistry I, models specifying Sense of Belonging predicting Impostor Syndrome provided superior fit in Organic Chemistry II based on model-fit criteria (see SI for these results.).

Direct and mediated effects of affective variables on exam performance

We first present the results of the SEM path analyses examining the influence of beginning-of-semester affective constructs on exam performance, followed by findings from the mediation analyses. The models for the paths of the pre-affective variables predicting both OC2 Average of Midterm Exams (Fig. 1A) and the OC2 Final Exam (Fig. 1B) produced comparable results. A significant positive relationship was observed between prior knowledge (PK: OC1 Final Exam) and OC2 exam performance (OC2 Avg Midterms: $\beta = 0.202$, $p < 0.001$; OC2 Final Exam: $\beta = 0.241$, $p < 0.001$), indicating that stronger prior content knowledge predicts higher performance on OC2 exams.

Conversely, imposter syndrome (IS) measured early in the semester showed a significant negative association with both OC2 average midterm ($\beta = -0.031$, $p < 0.022$) and OC2 final exam performance ($\beta = -0.072$, $p < 0.001$). A similar pattern emerged for Academic Mindset–Entity (AME), which negatively predicted OC2 final exam performance (OC2 Final Exam: $\beta = -0.048$, $p = 0.040$) but was not a statistically significant predictor of OC2 average midterm performance (OC2 Avg Midterms: $\beta = -0.027$, $p = 0.096$). These findings suggest that students with higher levels of early-semester imposter feelings or fixed mindsets tend to perform worse on exams. Interestingly, Sense of Belonging measured early in the semester did not significantly predict exam outcomes. Additionally, a significant negative relationship was found between pre_AME and Prior Knowledge (PK) (Fig. 1A (OC2 Avg Midterms: $\beta = -0.106$, $p < 0.001$); Fig. 1B (OC2 Final Exam: $\beta = -0.114$, $p < 0.001$)), suggesting that students endorsing stronger fixed-mindset beliefs at the start of the semester also had tended to have performed lower on the pre-knowledge assessment (Organic Chemistry I cumulative final).

While these direct relationships offer important insights, post-hoc mediation analyses revealed several significant indirect pathways (see Fig. 2, 3 and Table 1). Specifically, two

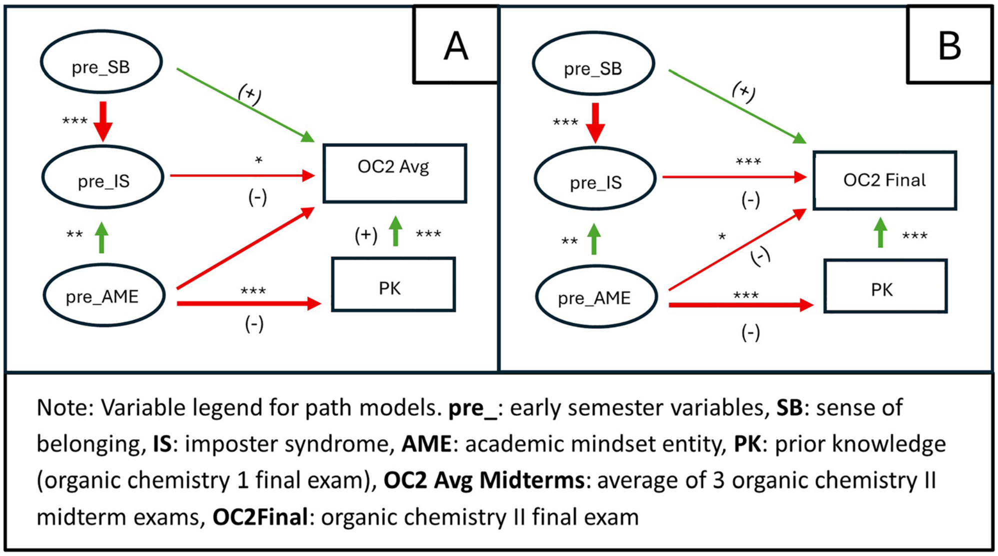

Fig. 1 Each SEM path model illustrates the relationships between latent constructs and observed exam performance outcomes. Latent variables (*e.g.*, *Sense of Belonging, SB*) are shown as ovals, and observed variables (*e.g.*, exam scores) are displayed as rectangles. Panels 1A and 1B present the models with the best overall fit for predicting performance on the OC2 midterm exams (average) and the OC2 final exam, respectively. Arrow colors indicate the direction of relationships (green = positive (+); red = negative (−)). Line thickness reflects the strength of each relationship: thicker lines represent larger parameter estimates and stronger connections between variables, whereas thinner lines denote smaller parameter estimates and weaker associations. Asterisks indicate significance levels: $p < 0.05$ (*), $p < 0.01$ (**), and $p < 0.001$ (***).

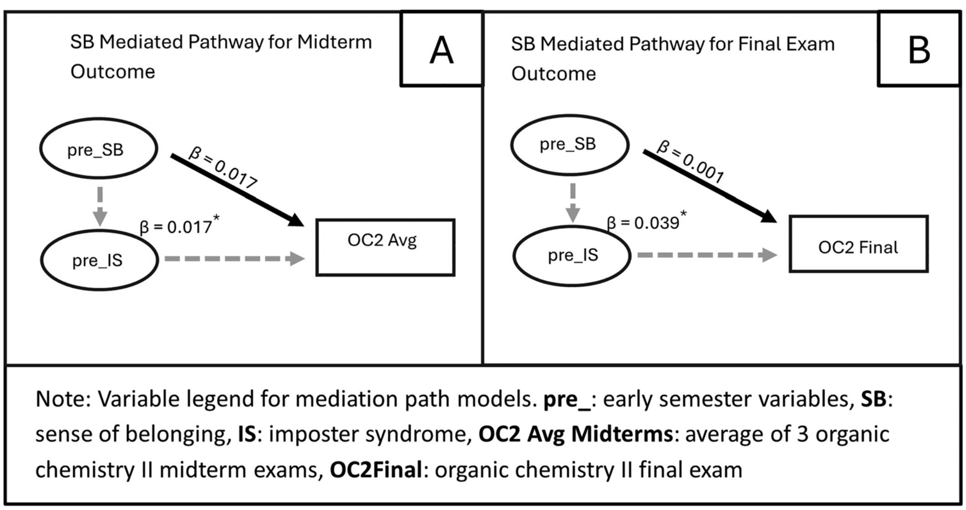

Fig. 2 Panels 2A and 2B depict the final mediation models describing the associations between sense of belonging (SB) and performance of the OC2 average midterm score and OC2 final exam, respectively, with imposter syndrome (IS) included as the mediator. Arrow colors and line styles indicate effect type: black solid arrows represent direct effects, and gray dashed arrows represent indirect effects. Unstandardized, bootstrapped coefficients (β) are displayed next to each direct path and near the center of each indirect pathway to indicate the direction and magnitude of the estimated effects. Asterisks indicate statistically significant pathways.

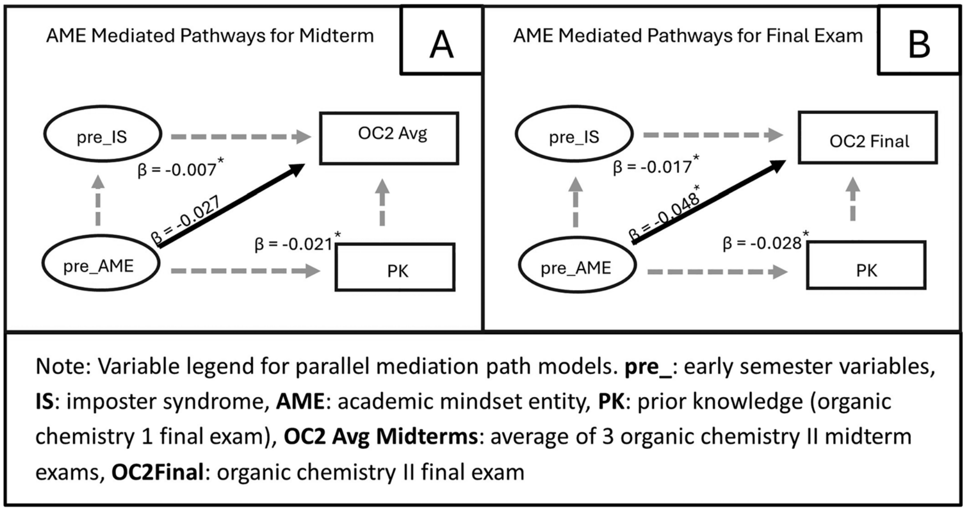

Fig. 3 Panels 3A and 3B present the final parallel mediation models describing the associations between academic mindset (AME) and performance on the OC2 average midterm score and OC2 final exam, respectively. Both models include imposter syndrome (IS) and prior knowledge (PK) as parallel mediators. Arrow colors and line styles indicate effect type: black solid arrows represent direct effects, and gray dashed arrows represent indirect effects. Unstandardized, bootstrapped coefficients (β) are displayed next to each direct path and near the center of each indirect pathway to indicate the direction and magnitude of the estimated effects. Asterisks indicate statistically significant pathways.

Table 1 Results of mediation and parallel mediation analyses for exam performance variables

Pathway[a]	Estimate[b] (β) [LLCI[c], ULCI[d]], S.E[e]
Mediated model (a)	
Direct	
pre_SB → OC2 Avg Midterms	0.017 [−0.013, 0.048], 0.016
Indirect	
pre_SB → pre_IS → OC2 Avg Midterms	**0.017 [0.002, 0.034], 0.008**
Total effects	**0.034 [0.005, 0.063], 0.015**
Direct	
pre_SB → OC2 Final	0.001 [−0.042, 0.042], 0.021
Indirect	
pre_SB → pre_IS → OC2 Final	**0.039 [0.018, 0.056], 0.010**
Total effects	**0.039 [0.003, 0.075], 0.018**
Parallel mediated model (b)	
Direct	
pre_AME → OC2 Avg Midterms	−0.027 [−0.060, 0.004], 0.016
Indirect	
pre_AME → PK → OC2 Avg Midterms	**−0.021 [−0.039, −0.007], 0.008**
pre_AME → pre_IS → OC2 Avg Midterms	**−0.007 [−0.017, −0.000], 0.004**
Total indirect	
(pre_AME → PK → OC2 Avg Midterms) + (pre_AME → pre_IS → OC2 Avg Midterms)	**−0.029 [−0.048, −0.012], 0.009**
Total effects	**−0.056 [−0.087, −0.022], 0.016**
Direct	
pre_AME → OC2 Final	**−0.048 [−0.091, −0.004], 0.022**
Indirect	
pre_AME → PK → OC2 Final	**−0.028 [−0.049, −0.011], 0.010**
pre_AME → pre_IS → OC2 Final	**−0.017 [−0.034, −0.003], 0.008**
Total indirect	
(pre_AME → PK → OC2 Final) + (pre_AME → pre_IS → OC2 Final)	**−0.045 [−0.072, −0.020], 0.013**
Total effects	**−0.093 [−0.136, −0.046], 0.023**

[a] Bolded pathways represent significant effects. [b] Bootstrapped unstandardized estimate. [c] LLCI = bootstrapped lower-level 95% confidence interval. [d] ULCI = bootstrapped upper-level 95% confidence interval. [e] Bootstrapped standard error.

mediation models were tested: (a) *pre_SB → pre_IS → OC2 Average Midterms/OC2 Final Exam* (Fig. 2); and model (b) *pre_AME → PK/pre_IS → OC2 Average Midterms/OC2 Final Exam* (Fig. 3).

As seen in Fig. 2 (and model (a) in Table 1), the indirect effect of Sense of Belonging on exam performance through impostor syndrome was statistically significant for both outcomes (OC2 Avg Midterms: β = 0.017, p = 0.033; OC2 Final

Exam: $\beta = 0.039$, $p < 0.001$), as were the total effects (OC2 Avg Midterms: $\beta = 0.034$, $p = 0.022$; OC2 Final Exam: $\beta = 0.039$, $p = 0.033$). The direct effects were not statistically significant (OC2 Avg Midterms: $\beta = 0.017$, $p = 0.266$; OC2 Final Exam: $\beta = 0.001$, $p = 0.976$), indicating that the association between sense of belonging and exam performance operated entirely through impostor syndrome (*i.e.*, full mediation).

As seen in Fig. 3 (and Model (b) in Table 1), a parallel mediation structure was tested in which Academic Mindset–Entity was associated with exam performance through both prior knowledge and impostor syndrome. For OC2 average midterm performance, the direct effect of Academic Mindset–Entity was not statistically significant ($\beta = -0.027$, $p = 0.096$). However, both indirect effects were statistically significant: the pathway through prior knowledge ($\beta = -0.021$, $p = 0.006$) and the pathway through impostor syndrome ($\beta = -0.007$, $p = 0.046$). The total indirect effect was also statistically significant ($\beta = -0.029$, $p = 0.002$), as was the total effect ($\beta = -0.056$, $p < 0.001$), indicating that the association between fixed mindset beliefs and midterm performance operated primarily through indirect pathways. Approximately 52% (0.029–0.056) of the total effect was accounted for by the combined indirect pathways, with the indirect pathway through prior knowledge representing a larger proportion of the total indirect effect (0.021–0.029 = 72%) than the pathway through impostor syndrome (0.007–0.029 = 24%).

For OC2 final exam performance, a significant direct effect of Academic Mindset–Entity was observed ($\beta = -0.048$, $p = 0.030$). In addition, two significant indirect effects emerged: one through prior knowledge ($\beta = -0.028$, $p = 0.005$) and one through impostor syndrome ($\beta = -0.017$, $p = 0.027$). The combined total indirect effect was statistically significant ($\beta = -0.045$, $p = 0.001$), as was the total effect of Academic Mindset–Entity, on OC2 final exam performance ($\beta = -0.093$, $p < 0.001$), indicating partial mediation. Approximately 52% ($0.048 \div 0.093$) of the total effect was attributable to the direct pathway, while 48% ($0.045 \div 0.093$) was explained through the combined indirect pathways. Of the mediated portion, the pathway through prior knowledge accounted for a larger share ($0.028 \div 0.045 = 62\%$) than the pathway through impostor syndrome ($0.017 \div 0.045 = 38\%$).

Discussion

This study explored the interrelationships between three affective variables (sense of belonging, imposter syndrome, and academic mindset entity) and their associations with student performance in an Organic Chemistry II (OC2) course. Student performance was measured using the average of three midterm exam scores (%) and a cumulative final exam score (%), while controlling for prior knowledge based on students' Organic Chemistry I (OC1) final exam performance. Data were collected from an OC2 course at a large, public, research-intensive university in the Mountain West region of the United States, enrolling a predominantly White and non-first-generation student population.

This study demonstrates that affective variables, specifically impostor syndrome, academic mindset, and belonging, play distinct yet interconnected roles in affecting achievement in OC2. By examining both direct and mediated effects, this study provides insight into how students' beliefs and social experiences influence their performance in second-year STEM coursework.

Finding 1: through direct and mediated paths, early-semester impostor syndrome and, to a lesser extent, fixed beliefs about intelligence predicted lower exam scores

Our findings show that when all three affective variables were examined together, early-semester academic mindset (entity beliefs) and impostor syndrome predicted lower exam scores through direct and indirect effects. After accounting for prior knowledge, students who entered OC2 with stronger fixed views of their academic ability tended to earn lower final exam scores, while higher levels of impostor feelings were associated with lower performance on both midterm and final exams. These findings suggest early-semester beliefs and emotional dispositions influence how students engage with the intellectual and emotional demands of OC2.

Furthermore, in addition to directly affecting the final exam performance, parallel mediation analyses revealed that academic mindset influenced performance through two distinct indirect pathways: imposter syndrome and prior knowledge. That is, students endorsing more fixed beliefs reported higher imposter scores, which undermined performance, and these beliefs appeared to be associated with a lower level of prior knowledge. This dual mechanism highlights the interplay between cognitive and emotional factors in determining outcomes. Kumar and Jagacinski (2006) found that impostor fears were significantly associated with endorsement of an entity theory of intelligence, particularly among women, and correlated with heightened test anxiety and diminished confidence in one's intellectual ability. This pattern aligns with Clance and Imes's (1978) characterization of impostorism as a persistent internalization of self-doubt despite evidence of competence. Similarly, Canning *et al.* (2020) observed that students' fixed-mindset beliefs at the beginning of a semester predicted stronger impostor experiences across STEM courses, a finding seen by studies linking impostor feelings to evaluative threat and social comparison in competitive academic environments (Leary *et al.*, 2000; Vaughn *et al.*, 2020). Additionally, students who perceive intelligence as a fixed trait or experience persistent self-doubt may interpret common academic difficulties as evidence of personal inadequacy rather than a part of the learning process (Dweck, 2006; Yeager and Dweck, 2012; Canning *et al.*, 2019). Such student interpretations can undermine confidence and motivation (Bandura, 1997; Kumar and Jagacinski, 2006), increase anxiety and avoidance behaviors (Leary *et al.*, 2000; Vaughn *et al.*, 2020), and ultimately hinder achievement even among otherwise well-prepared students (Canning *et al.*, 2020). Taken together, these findings illustrate how fixed mindset beliefs and impostor feelings operate as interconnected affective risks that can undermine performance.

These results align with a growing body of research showing that imposterism and mindset influence performance across

STEM contexts. For example, across STEM courses, students who experienced higher levels of imposterism or perceived ability as fixed, or believed their instructors hold fixed mindset views reported lower motivation, confidence, or sense of belonging (Canning *et al.*, 2019; Canning *et al.*, 2020; Muenks *et al.*, 2020; Vaughn *et al.*, 2020). Recent chemistry-focused studies reinforce this trend. For example, Kattoum *et al.* (2024) found that students who believe their instructors hold fixed views of ability report lower belonging and achievement. Additionally, Santos and Mooring (2022) showed that students' chemistry mindset varies with the type of challenge they encounter and how they interpret that challenge; in particular, students who interpreted their difficulties as evidence of low or fixed chemistry ability were less likely to report overcoming these challenges and earned lower course performance than peers whose challenges did not center on perceived chemistry ability. In General Chemistry I, Bustamante and Frey (2026) found that both impostor feelings and fixed mindsets predicted first midterm and final exam performances after accounting for prior knowledge. Extending the analysis to OC2, we observed that impostor feelings negatively influenced both midterm and final exam performances. Additionally, academic mindset–entity showed a direct negative association with final exam scores and moreover impacted midterm and final exam performance indirectly *via* impostor feelings and prior knowledge. Collectively, these findings suggest that the same affective patterns influencing learning in early introductory chemistry courses continue to matter as students move into OC2, a course taken after students have successfully completed three semesters of college-level science courses.

These two linked affective factors reinforce one another; *i.e.*, a fixed mindset amplifies self-doubt, while impostor thoughts further diminish confidence, motivation, and help-seeking. Together, these factors shape how students interpret feedback and challenges; students with stronger impostor fears often attribute success to luck or see constructive criticism as evidence of inadequacy (Leary *et al.*, 2000; Vaughn *et al.*, 2020). In courses requiring sustained problem solving and abstraction, such as organic chemistry, interpreting difficulty as evidence of fixed ability can discourage persistence when challenges arise (Towns, 2013; Canning *et al.*, 2020). Parallel mediation analyses reinforce this dynamic, revealing that mindset influences performance both directly and indirectly through imposter syndrome and prior knowledge. These results highlight the dual cognitive and emotional pathways through which beliefs about ability affect learning. Furthermore, while impostor syndrome and mindset exert the most substantial influence on performance in the combined model, belonging contributed meaningfully through an indirect pathway, highlighting the nuanced interactions among these affective variables.

These results directly address our research question 1 by showing that two of the early-semester affective constructs, impostor syndrome and academic mindset–entity, significantly predicted exam performance, even after accounting for prior knowledge. Impostor syndrome exerted consistent direct negative effects on both performance measures, whereas fixed-ability beliefs negatively influenced performance through both direct and mediated pathways (*via* imposter syndrome and prior knowledge). These patterns confirm that early-semester affective beliefs meaningfully shape achievement in OC2.

Finding 2: belonging predicts performance through the mediating role of impostor syndrome

When examined in connection with imposter syndrome and academic mindset, sense of belonging showed no direct effect on exam scores. However, its influence is seen through imposter syndrome, underscoring the importance of social integration in affecting performance. Students who reported lower belonging at the start of the semester reported stronger impostorism, which in turn predicted lower performance for both midterm and final exams scores. This mediated relationship suggests that belonging influences emotional responses to challenge rather than exerting a direct impact on performance.

This pattern contrasts with prior SEM path analysis findings in General Chemistry 1 (Bustamante and Frey, 2026), where imposter syndrome mediated the interaction between mindset and performance but not between belonging and performance. Our results suggest that in OC2, belonging may become more consequential, possibly because OC2 may heighten evaluative pressure and social comparison. Prior research supports this interpretation: students who feel less connected to their peers or the classroom community tend to report greater self-doubt and lower engagement (Leary *et al.*, 2000; Vaughn *et al.*, 2020; Shin and Lytle, 2024), as well as lower belonging can heighten self-doubt and undermine confidence (Fong *et al.*, 2024). Whereas those who experience higher belonging in their learning environments report higher motivation and persistence in STEM contexts (Walton and Cohen, 2007; Fink *et al.*, 2020; Edwards *et al.*, 2023).

Within the current course setting (*i.e.*, OC2), students' interpretations of their ability and responses to difficulty appear to be influenced by their levels of impostorism. Students who experience stronger impostor fears may attribute success to luck or interpret normal academic struggle as confirmation of limited ability (Kumar and Jagacinski, 2006; Canning *et al.*, 2020). Because belonging influences how students evaluate themselves relative to peers, fostering community may weaken this self-doubt cycle and reduce imposter-related barriers to achievement (Fink *et al.*, 2020). Interventions that normalize challenge, emphasize growth, and promote community (Dweck, 2006; Walton and Cohen, 2007; Yeager and Dweck, 2012; Fink *et al.*, 2020; Zanchetta *et al.*, 2020; Para *et al.*, 2024) may therefore help weaken this impostor pathway. Although empirical research directly targeting impostorism in chemistry is limited, studies suggest that normalizing these experiences and cultivating supportive classroom environments can help students manage self-doubt and sustain engagement (Canning *et al.*, 2019; Lytle and Shin, 2023; Fong *et al.*, 2024).

Finding 2 addresses both research questions 1 and 2. With respect to research question 1, belonging did not directly predict exam performance; instead, its influence with performance was explained entirely through its relationship with imposter syndrome. With respect to research question 2, the significant pathway from belonging to impostorism demonstrates how these constructs are related at the beginning of the semester: lower belonging predicts stronger impostor feelings, which subsequently undermine performance.

Finding 3: continued influence of impostor syndrome beyond general chemistry

Impostor syndrome remained a significant predictor of student performance in Organic Chemistry II, indicating that its influence extends beyond first-year coursework. Early-semester impostor feelings negatively predicted both midterm and final exam performances, despite students' prior success in the General Chemistry series and Organic Chemistry I. These results extend previous findings about impostor syndrome from General Chemistry I (Bustamante and Frey, 2026) and align with prior literature characterizing impostorism as a commonly recurring affective experience among students, not limited to a single course or academic context (Clance and Imes, 1978; Canning *et al.*, 2020; Vaughn *et al.*, 2020).

The persistence of these beliefs across chemistry contexts suggests that experience and achievement alone may not be sufficient to mitigate imposter feelings. Prior research indicates that impostor thoughts often recur despite objective success, as students attribute performance to external factors rather than ability (Leary *et al.*, 2000; Kumar and Jagacinski, 2006). These patterns are consistent with studies linking impostor fears to elevated anxiety, self-criticism, and diminished confidence and belonging (Leary *et al.*, 2000; Canning *et al.*, 2020; Vaughn *et al.*, 2020; Shin and Lytle, 2024). Moreover, common structural aspects of organic chemistry, such as the emphasis on high-stakes assessments, rapid content coverage, and performance-oriented grading, may reinforce impostor experiences, particularly when struggle is perceived as evidence of fixed ability rather than a normal part of learning (Dweck, 2006; Yeager and Dweck, 2012; Towns, 2013; Canning *et al.*, 2019).

Finding 3 reinforces the results for research question 1 by demonstrating that impostor syndrome remains a robust predictor of OC2 performance, extending its influence beyond general chemistry. It also complements research question 2 highlighting that impostorism functions as a central affective mechanism linking early-semester mindset beliefs and social belonging to performance outcomes.

Together, these three findings show that impostor syndrome, fixed mindset beliefs, and sense of belonging form an interconnected affective network that shapes student performance in Organic Chemistry II. Impostor syndrome emerged as a consistent predictor of exam outcomes, fixed mindset beliefs influenced performance both directly and through their relationships with impostor feelings and prior knowledge, and belonging contributed indirectly through its connection to impostorism. The persistence of these patterns beyond General Chemistry indicates that these affective experiences do not simply decrease as students advance in the curriculum, suggesting the importance of addressing them throughout the STEM pathway. In the following section, we discuss implications for teaching practices and course design that may help mitigate these affective barriers and promote student success.

Implications for instruction

These findings have several instructor implications, including for instructors teaching second-year STEM courses. First, instructors should recognize that students begin OC2 with a wide range of affective experiences and beliefs that influence how confident and connected they feel, even before engaging with course content or assessments. Although these students have completed multiple semesters of college-level science, many still report impostor feelings, fixed views of ability, or lower belonging. Instructors can help mitigate these concerns by setting early expectations that normalize struggle and emphasize the importance of progress throughout the course (*e.g.*, discussing how learning complex material takes time or sharing stories of persistence from former students) (White *et al.*, 2021). Additionally, small reflection activities after exams can prompt students to identify strategies that worked and to plan adjustments, reinforcing the link between effort and improvement (Mutambuki *et al.*, 2020; Walck-Shannon *et al.*, 2024). Moreover, instructors might include examples of scientists from various backgrounds, experiences, and career paths to demonstrate that success in chemistry is not limited to a particular type of student and that the field is accessible to everyone (Schinske *et al.*, 2016; Yonas *et al.*, 2020; Rivera *et al.*, 2024).

Second, the observed relationships among academic mindset, impostor syndrome, and performance highlight the importance of fostering a growth-mindset culture within chemistry instruction. Instructors can emphasize effort and learning from mistakes by allowing students to revisit quiz or exam items for partial credit or by providing process-focused feedback that highlights reasoning over correctness alone (Hattie and Timperley, 2007; Tanner, 2013; Driessen *et al.*, 2020). Furthermore, modelling intellectual humility, such as acknowledging when a problem is challenging or showing how one's own understanding continues to develop, signals that ability can grow with effort and feedback (Dweck, 2006; Yeager and Dweck, 2012). Conversely, language suggesting that certain students are "naturally good" at chemistry can inadvertently heighten impostor fears and discourage persistence (Canning *et al.*, 2020; Vaughn *et al.*, 2020; Shin and Lytle, 2024).

Third, since impostor syndrome emerged as both a direct predictor of exam performance and a mediator for both mindset and belonging, instructors should take intentional steps to reduce impostor feelings in their classrooms. Students experiencing impostor thoughts often attribute success to luck and disengage when they feel less capable than peers (Clance and Imes, 1978; Leary *et al.*, 2000; Canning *et al.*, 2020; Vaughn *et al.*, 2020). Creating spaces where students can discuss problem-solving strategies, compare reasoning, and realize that uncertainty and struggling are common can help normalize challenges. Approaches such as structured group work, exam debriefs, or brief peer-validation activities encourage collaboration over competition (Leopold and Smith, 2019; Szteinberg *et al.*, 2020; Dabkowski *et al.*, 2025). Framing learning as a shared process and reminding students that progress develops through consistent effort and effective study habits can strengthen confidence and engagement (Yeager and Dweck, 2012; Dunlosky *et al.*, 2013). Additionally, active-learning approaches such as Learning Assistant Model (Barrasso and Spilios, 2021), Peer-Led Team Learning (Frey and Lewis, 2023), Supplemental Instruction (Arendale, 2002), and POGIL (Moog, 2014), provide regular opportunities for students to share reasoning and learn from peers. Active learning approaches have been shown to improve achievement (Freeman *et al.*, 2014), increase motivation (Cicuto and Torres, 2016), and strengthen classroom community (Fong *et al.*, 2024; Chouvalova *et al.*, 2026). Together, these strategies help students view difficulty as a normal part of mastering chemistry and can build more inclusive and supportive learning environments.

Last, the mediated role of belonging through impostor syndrome underscores the importance of building supportive classroom communities. Students who feel disconnected are more likely to experience self-doubt and interpret challenges as evidence of inadequacy, which can undermine persistence (Fink *et al.*, 2020, 2023b). Instructors can foster belonging by incorporating collaborative learning structures, validating multiple perspectives, and signaling that all students are valued contributors to the learning environment (Walton and Cohen, 2007; Fink *et al.*, 2020; White *et al.*, 2021; Edwards *et al.*, 2023). Creating classroom norms that frame challenge as normal, emphasize a growth mindset, and build a sense of community can help reduce impostor-related barriers and encourage persistence (Yeager and Dweck, 2012; Fink *et al.*, 2018, 2023a, 2023b; Chouvalova *et al.*, 2026). Although studies focused specifically on impostorism in chemistry are limited, existing evidence suggests that supportive practices and clear messages affirming belonging can lessen self-doubt and promote engagement (Canning *et al.*, 2019; Lytle and Shin, 2023; Fong *et al.*, 2024).

Limitations

Several limitations should be considered when interpreting the findings of this study. First, the data were collected from a single large, research-intensive institution and from one section of Organic Chemistry II. Moreover, although the institution enrolls students with a range of academic backgrounds, it remains a predominantly White campus, and most students in OC2 are not first-generation college students. Institutional culture and student demographics, course structure, and instructional practices vary widely across institutions; therefore, the generalizability of these results may be limited. Replicating this work across a range of institutional contexts would provide a broader understanding of how these affective constructs operate in organic chemistry.

Second, although early-semester measures of mindset, impostor syndrome, and belonging were collected prior to students receiving performance feedback, all affective constructs were self-reported. Self-report data may be influenced by social desirability, students' interpretations of item wording, or momentary fluctuations in mood (Podsakoff *et al.*, 2003). Third, another potential limitation concerns the measurement of sense of belonging. The unidimensional CFA for this construct yielded a "perfect" model fit, which can indicate limited variability or model saturation. However, additional psychometric evidence supported the internal structure of the measure, and sense of belonging did not emerge as a statistically significant direct predictor of either the average midterm or final exam. Taken together, these findings suggest that the role of belonging in our models does not compromise the overall interpretation of results. Additionally, the belonging measure used in this study was restricted to the sense of belonging subscale because the belonging uncertainty items did not meet psychometric criteria in our sample. As a result, the analysis captures only part of the broader belonging construct.

Fourth, the study's analytic approach focused on relationships among early-semester affective constructs and exam performance, taking prior knowledge into account *via* the OC1 final exam. Although using the OC1 final exam provides a consistent measure of preparation, it is only one indicator and may not fully represent students' conceptual readiness, study habits, or prior course experiences. Moreover, the sample included students who completed all surveys and had accessible exam scores, which may exclude students who were absent, withdrew, or disengaged from the course. These students may have different affective profiles, which could influence the strength or nature of the relationships observed here.

Last, the traditional high-stakes assessment structure of the OC2 course represents a contextual limitation, which may have primed fixed ability beliefs or elevated evaluative concerns prior to entering the course. However, students completed the pre-semester survey in the second week of class, before they had substantial exposure to the course or any performance feedback. Future work comparing courses with alternative structures, such as mastery-based grading or more frequent low-stakes assessments, could help clarify how instructional contexts shape students' affective starting points. Additionally, qualitative approaches, such as interviewing a subset of students early in the semester, could provide deeper insight into what factors shape students' initial mindset beliefs, belonging, or evaluative concerns. Such qualitative work would complement the quantitative findings.

Notably, prior work in General Chemistry has already demonstrated the importance of impostor syndrome and academic mindset in influencing student outcomes, underscoring the value of examining these constructs across the course sequence. Taken together, these limitations highlight the need for continued research that examines affective constructs across multiple course levels, incorporates longitudinal designs, and uses mixed methods to fully characterize how students experience organic chemistry.

Conclusion

In this study, we contribute to the growing body of work on the role of affective factors in shaping achievement in undergraduate

STEM courses. Specifically, we examined how three early-semester factors, sense of belonging, impostor syndrome, and academic mindset entity, interrelate and influence exam performance in Organic Chemistry II. Our findings indicated that both academic mindset and impostor syndrome both directly predict achievement, while mediation analyses revealed that impostor syndrome is a key mediator linking mindset and belonging to performance. Furthermore, parallel mediation analyses showed that academic mindset influences exam outcomes through two distinct pathways: impostor syndrome and prior knowledge. This dual mechanism underscores the interplay between cognitive and emotional factors in determining success.

Importantly, these results showed that fixed beliefs about ability and elevated impostor feelings, measured before students engaged with the structure and assessments of the course, can negatively affect both midterm and final exam outcomes. Moreover, the mediation pathways demonstrated that these affective variables do not operate independently in affecting performance. The persistence of these patterns in Organic Chemistry II suggests that affective influences remain relevant beyond first-year coursework. Even after successfully completing multiple semesters of college-level chemistry, many students continue to enter chemistry courses with fixed-ability beliefs, lower levels of belonging, or persistent impostor thoughts, and these have measurable effects for their performance.

Descriptively, comparison of early-semester affective variables between General Chemistry I and Organic Chemistry II suggests similarity in descriptive anchors in students' affective profiles at the start of the term. In both courses, when comparing the Likert-scale anchors of early-semester average scores, impostor syndrome aligned with "somewhat disagree," sense of belonging with "agree," and academic mindset with "slightly above agree." It is important to note that these datasets reflect different students and different cohorts (and were collected in different terms), so these similarities should not be interpreted as cohort comparisons or as evidence of equivalence or change over time. Rather, they provide contextual, non-inferential alignment between these two courses. To evaluate stability within students using appropriate statistical comparisons, we are conducting a longitudinal study that follows the same students from General Chemistry I through Organic Chemistry II.

Our study findings point to several implications for instruction. Creating classroom environments that emphasize growth, normalize challenges, and encourage open communication between students and instructors may help lessen the impact of impostor feelings and fixed-ability beliefs on student performance. In addition, acknowledging the range of affective experiences students carry with them into Organic Chemistry II, and intentionally designing pedagogical practices that affirm students' capabilities and encourage their sense of connections, may improve these affective variables, increase engagement, and their academic outcomes. Ultimately, supporting student success in STEM requires attending to both conceptual understanding and the beliefs, emotions, and prior experiences that students bring into the learning environment, even into second year STEM courses.

At the same time, the present findings raise important questions about why students enter OC2 with these particular affective profiles. While our quantitative analyses identify meaningful relationships among belonging, impostor syndrome, and mindset at the start of the semester, the results do not reveal the specific experiences, prior coursework, or contextual classroom factors that shape these beliefs and feelings. Future research that incorporates qualitative methods, such as interviews or focus groups with selected students, could offer a more fine-grained view of possible sources that contribute to lower belonging, elevated impostor feelings, or fixed-ability beliefs. Such work would help uncover the processes shaping these affective states and inform more intentional and evidence-based approaches to supporting students as they transition into second-year chemistry.

Conflicts of interest

There are no conflicts to declare.

Data availability

The data are not publicly available as approval for this study did not include permission for sharing data publicly.

Supplementary information (SI) is available: EFAs and CFAs for the measures (academic mindset entity, and imposter syndrome); CFA for social belonging measure; SEM path model details; mediation analyses. See DOI: https://doi.org/10.1039/d6rp00023a.

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