

# ***WHY STUDENTS WITHDRAW FROM ONLINE STEM COURSES***

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This study addresses the STEM workforce shortage by examining online STEM course withdrawals. This article categorizes withdrawal reasons using a two-tiered coding system based on a theoretical framework. Institutional data, analyzed through qualitative methods and descriptive statistics, showed withdrawal rates between 2.0–9.6%, with no significant differences between general education and degree support courses or STEM disciplines. External and environmental factors accounted for 49% of withdrawal reasons, followed by institutional characteristics (23%). These findings, especially regarding external and environmental factors, offer crucial insights for designing interventions to enhance online course persistence, bridging the STEM workforce gap.

**Keywords:** Academic Persistence, Online Courses, STEM Education, Withdrawal (Education), Undergraduate Students

As an increasing number of courses are taught asynchronously online, it is essential to understand how this may impact student outcomes. The literature has noted increased drop and withdrawal rates from online courses compared to traditional courses (Atchley et al., 2013; Jaggars et al., 2013; Murphy & Stewart, 2017; Cottrell, 2021). Withdrawal rates from online courses reported in the literature vary, from as low as 2% to 80% (Atchley et al., 2013; Flood, 2002; Park & Choi, 2009; Pierrakeas et al., 2004). Differences could be based on selection bias (single program or course) or how the researchers defined and analyzed withdrawal. Some studies counted failing grades as a with-

drawal, while others only considered official withdrawals, not course drops early in the term (Park & Choi, 2009). Online undergraduate STEM persistence is problematic and has warranted attention in the educational community (Pedraza & Chen, 2022). Because of the gap between supply and demand for STEM professionals, understanding persistence in STEM courses – particularly online STEM courses – is increasingly important.

This paper evaluates nuanced withdrawal reasons from online undergraduate STEM courses. While most withdrawal studies report aggregate withdrawal numbers, this study aims to understand why interventions and supports

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can be designed to support student persistence. There is a noted need for growth in student support services offered for online students (Kember et al., 2023), which will require a detailed understanding of the factors influencing persistence. While accessing the data will vary by institution, the measures taken in this study can be informative across institutions, particularly related to how withdrawal reasons were coded for thematic analysis.

## LITERATURE REVIEW

Various theories have been outlined regarding student persistence in a course. In the *Student Integration Model*, persistence is a factor in how students are integrated into the institution academically and socially to have a sense of belonging (Tinto, 1987). In the *Social Cognitive Theory*, the student's individual belief of control over the outcome of their education (based on control of motivation, expectations, attitudes, engagement, and self-efficacy) positively impacts achievement and persistence (Bandura, 2002). Overlapping with the social cognitive theory, the *Model of Student Departure* identifies persistence as a factor of student behavioral intentions (beliefs, attitudes, and decisions), both internal and external to the institution (Bean, 1990).

The research into online student attrition mirrors these persistence theories (Heilporn & Lakhali, 2022; Lee & Choi, 2011). The *Distance Education Student Progress Model* applied Tinto's model to online learning but expanded on the social aspects that can influence persistence (Kember, 1995). In this model, social integration in the online learning environment leads to academic integration, connecting student attrition to the ability to integrate their educational demands with social obligations, with lower success for students with an attribution of perceiving control as external (Kember, 1995). The *Composite Persistence Model* (Rovai, 2003) applied Tinto and Bean's models to online students, exploring factors before and after admission, including internal and

external variables. Rovai's model was further refined to consider factors prior to and during engaging in the online course (Park & Choi, 2009). However, even today, researchers note the difficulty in translating the foundational student persistence models into the online learning environment (Kember & Fan, 2023).

Beyond these models, many researchers have aimed to identify and categorize factors influencing online course persistence. A 2011 review article examined 35 publications to identify factors that influence persistence in online courses, arriving at three over-arching categories: students, course or program, and environmental (Lee & Choi, 2011). The authors identified strategies to promote online course persistence, including understanding student challenges, providing high-quality courses and student support services, and addressing environmental issues and psychological stressors. A 2012 review article evaluated 20 publications and identified 10 factors that promote online course persistence, like social connectedness, and barriers to persistence, such as student skills or family responsibilities (Hart, 2012). Importantly, this paper emphasizes that non-academic barriers to persistence can be mitigated with appropriate student supports. A 2012 research paper explored differences between students who completed an online course and those who did not, identifying locus of control and metacognitive self-regulation skills as key predictors of persistence (Lee et al., 2013).

Recently, more review articles on the topic have been published. A 2019 review article evaluated 40 publications, focusing on factors related to the institution, the course or instructor, and the student (Muljana & Luo, 2019). Within these categories, they reported predominant withdrawal reasons related to institutional support, program difficulty, lack of belonging, and course design. Like Lee and Choi, the authors suggested strategies to improve online course persistence, including early intervention, comprehensive support structures, faculty professional development aimed at effective communication, high-quality feedback,

and strategies to foster positive student behavior and improved stakeholder collaboration. A 2020 review article evaluated 26 papers to identify persistence factors and effective strategies to address them (Delnoij et al., 2020). They reported cognitive predictors of course attrition of prerequisite skills and study strategies, non-cognitive predictors of self-efficacy, goals, and intentions, institutional adjustments, situational predictors of employment and support network, and institutional predictors of faculty-student interactions. The authors categorize all these as *modifiable*. They suggest interventions for online contexts, including motivational contact and instruction interventions, coaching, remedial teaching, and peer mentoring. They note that evaluating intervention strategies in online contexts was challenging as studies had inconsistent results and, in some cases, included multiple interventions, making it challenging to interpret results.

Demographics and learner characteristics show mixed results in predicting online course persistence. A comprehensive analysis of reviews and meta-analyses of the influence of demographic factors on noncompletion reported inconsistent results related to socioeconomic status, age, gender, and parent's education. For example, some studies reported males to have higher withdrawal rates from online courses (Aragon & Johnson, 2008; McKinney et al., 2018; Packham et al., 2004; Willging & Johnson, 2009), while others reported no significant differences by gender (Park & Choi, 2009; Pierrakeas et al., 2004; Wladis et al., 2015b). Additionally, some studies showed that age did not predict persistence in an online course (Levy, 2007; Park & Choi, 2009), while other studies showed significant differences by age (McKinney et al., 2018; Pierrakeas et al., 2004). Ethnicity was not found to be a moderating variable for online course persistence in some studies (Wladis et al., 2015b; O'Neill et al., 2011), while other studies showed minorities were more likely to withdraw from an online program (McKinney et al., 2018; Willging & Johnson, 2009).

This uncertainty in the literature is important to note as students enrolled in online STEM courses tend to be non-traditional students (e.g., part-time enrollment, full-time employment), with minority students (particularly Black and Hispanics) and men underrepresented in online STEM courses, while women are more likely to enroll in STEM courses online (Wladis et al., 2015b, 2015a). Focusing specifically on online STEM courses and aligned with the larger body of evidence for online courses, demographic and learner characteristics had variable influences on persistence in online STEM courses. Successful completion of online STEM courses has been positively correlated to age (Wladis et al., 2015b; Xu & Jaggars, 2013). GPA and prior performance in online courses were predictors of STEM course outcomes (Wladis et al., 2015a; Xu & Jaggars, 2013). Some studies reported lower persistence for female students (Wladis et al., 2015a), while others showed males had reduced persistence in online STEM courses (Xu & Jaggars, 2013). Some studies showed no significant differences in online STEM persistence based on ethnicity (Wladis et al., 2015a), while others demonstrated that black students had lower persistence (Xu & Jaggars, 2013). However, sample size, institution type, and the limited number of studies limit these relationships' generalizability.

## ***THEORETICAL FRAMEWORK***

The theoretical framework for understanding student persistence in online undergraduate STEM courses is based on the theories and dimensions identified in the existing models and foundational research presented in the literature review above. It is organized into four main categories: External and Environmental Factors, Internal and Personal Factors, Learner Characteristics and Skills, and Institutional Characteristics. A conceptual framework organizing elements of these key dimensions according to multiple student persistence models is presented in Figure 1.

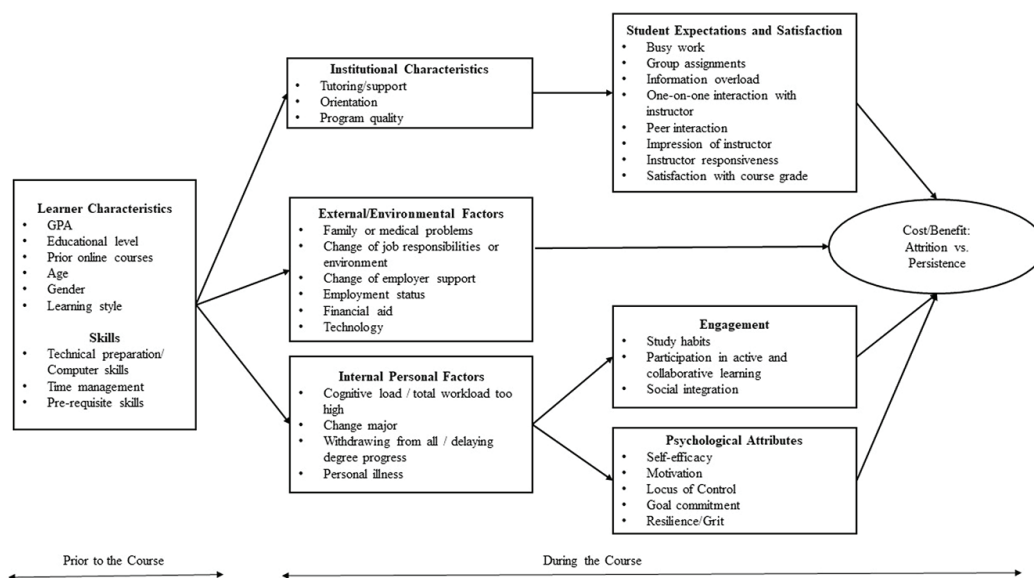


FIGURE 1

*Conceptual Framework for Student Online Course Withdrawal*

Learner characteristics and skills are a primary category for evaluating withdrawal reasons, covering specific traits and skills. Previous degree(s), number of academic credits earned, nearness to graduation, and amount of professional experience impact a student's persistence in an online course (Cochran et al., 2014; Dupin-Bryant, 2004; Levy, 2007; Xenos et al., 2002). Previous experience with online courses, successful or not, is a predictor of persistence (Dupin-Bryant, 2004). Grade point average (GPA) consistently correlates to online course persistence (Cochran et al., 2014; Harrell & Bower, 2011; Jaggars et al., 2013; McKinney et al., 2018).

Institutional characteristics influence online course persistence. Within a course, perceptions of instructor practices, LMS dialogue, and perceptions of peer support were predictors of self-reported intention to persist in an online STEM course (Kittur et al., July 2021). Clear communication of course relevance may improve persistence (Ivankova & Stick, 2006; Levy, 2007; Park & Choi, 2009). Additionally,

nuanced factors like perceived course difficulty and expectation of success in the course were positive and significant predictors of self-reported course persistence intentions (Kittur et al., January 2021). Instructional presence in an online course is valued by students (Angelino et al., 2007; Herbert, 2006; Joyner et al., 2014), but students report lower instructor presence in online courses (Jaggars, 2014). However, the importance of instructional presence to student persistence is debated. Several works report no correlation between the learning community and persistence (Drouin, 2008; Pigliapoco & Bogliolo, 2008), while others suggest that the quality of interactions and feedback are essential factors in persistence (Hart, 2012; Ivankova & Stick, 2006; Liu et al., 2009; Ojokheta, 2010). Interestingly, one study showed that increased instructor-student comments in an online course were correlated to decreased success, measured as the combined withdrawal and course failure (Moore, 2014). The peer support hypothesis predicts that strong peer connections in an online course limit the im-

pect of isolation as a barrier to persistence (Faulconer et al., 2018; Moore, 2014; Sinclair, 2017). Narrowly focusing on STEM, student persistence in online courses includes pedagogical methods employed (Lou et al., 2006) and social presence (Burch, 2018; Liu et al., 2009).

The external and environmental factors category encompasses elements beyond the individual student and institution that may influence student persistence. Empirical research on these factors is emerging (Heilporn & Lakhali, 2022). Military deployment can often occur without warning and can reduce access to reliable Wi-Fi. One study found that half of military students who continued online coursework while deployed experienced role conflict (Trettin, 2017). Students may experience changes in their access to funding and financing (e.g., student loans and scholarships). The availability of needs-based financial support has improved successful STEM course completion (Castleman et al., 2018), though this study was not performed in the context of online courses. Personal conflicts can reduce the capacity to engage in online education, such as non-professional schedule obligations (e.g., volunteerism or public service like jury duty) or family responsibilities like caring for young or elderly family members (Lee & Choi, 2011; Hart, 2012; Muljana & Luo, 2019). Because many online students are employed, there can be professional conflicts as well, including schedule changes, relocations, and changes in workload and responsibility that could unexpectedly interfere with the capacity to engage in an online course (Lee & Choi, 2011; Hart, 2012; Muljana & Luo, 2019; Delnoji et al., 2020). While internet connectivity access and affordability have significantly improved in recent years, particularly in rural regions, uncertain or unreliable access could be a significant limitation for engaging in online coursework and could influence a decision to persist. Internet access influences students' decisions to engage in online courses (Huntington-Klein et al., 2017). A student's external support network (support from friends, colleagues, family, and

online community) is essential in online course persistence (Hart, 2012; Park & Choi, 2009).

The internal and personal factors category focuses on various psychological and cognitive dimensions that may influence an undergraduate student's persistence in an online STEM course. Personal illness or health issues can disrupt a student's ability to engage consistently in coursework (Hart, 2012). Cognitive load is another factor that may influence persistence in online courses (Kinsey, 2022), which is influenced by the inherent difficulty of the course work (intrinsic load), the effort to build a comprehensive knowledge schema (germane load), and the clarity of the presentation of the content and activities (extraneous load). Another personal withdrawal motivation may be that a student decided to change majors, either because they learned they did not want to continue with the original path or they found a new passion along the way that they want to pursue. Students who engage in the course by interacting with the course materials, instructor, and peers are more likely to complete an online course (Suresh et al., 2018), which could be due to a variety of factors such as their study habits or the inclusivity and interactivity of the online learning environment. Self-efficacy (a student's belief that they will be successful) influences persistence (Delnoji et al., 2020). Intrinsic motivation is another key personal factor for persistence (Kinsey, 2022). Finally, goal commitment can maintain persistence despite obstacles and setbacks (Hart, 2012).

Also, time management and computer skills can influence performance in online courses (Lee & Choi, 2011; Muljana & Luo, 2019). Time management is critical to pace engagement and meet expectations, particularly in asynchronous online courses. Often, these courses include interactive components where peers rely on the engagement of others, like in discussions, workshops, or social annotation activities. Some student learning styles are not conducive to an asynchronous online learning environment (Harrell & Bower, 2011). Locus of control and metacognitive self-regulation skills are also important for persistence (Lee

et al., 2012; Roubides, 2016). A 2005 study identified that locus of control and financial aid alone predicted persistence in online courses with 75% accuracy (Morris et al., 2005).

External to the course, support programs like tutoring, advising, and mentoring can influence a student's persistence (Lee & Choi, 2011). The program's quality, including the curriculum and resources available to students, is also important (Muljana & Luo, 2019). Student perceptions of the instruction, their interactions with the instructor, the quantity and quality of feedback provided, and their interactions with peers can also be driving factors for persistence (Lee & Choi, 2011; Hart, 2012; Muljana & Luo, 2019; Delnoji et al., 2020). Students may also find that the course topics can encourage persistence, particularly if they align with their interests and career goals or have a level of choice or autonomy to select topics of personal relevance (Hart, 2012; Lee et al., 2015). Effective course design, including assessment and activity design choices, is critical and is a long-standing active area of research for online STEM courses (Lee & Choi, 2011; Muljana & Luo, 2019). Furthermore, a student may find that online learning could be better for them or that subject. Finally, students may leave a course if they do not feel they can achieve their performance goal (Martinez-Carrascal & Sanch-Vinuesa, 2021).

A student's persistence in a course likely has multiple dimensions. For example, a student may fall ill with COVID-19, delaying their progress. If additional family members fall ill next and require care, the student may be further delayed in their coursework. If the illness requires medical intervention and reduced hours at their place of employment, they may now face financial burdens that could influence their ability to persist in the course. Detailed information on the student's motivation to withdraw is needed to understand what supports or interventions could have promoted their successful course completion. Some elements of online course persistence take time to address by an institution. Persistence in online courses is well-studied, and there is some

existing data on persistence in online STEM courses. However, withdrawal reasons are complex and less studied. We seek to answer the following research questions:

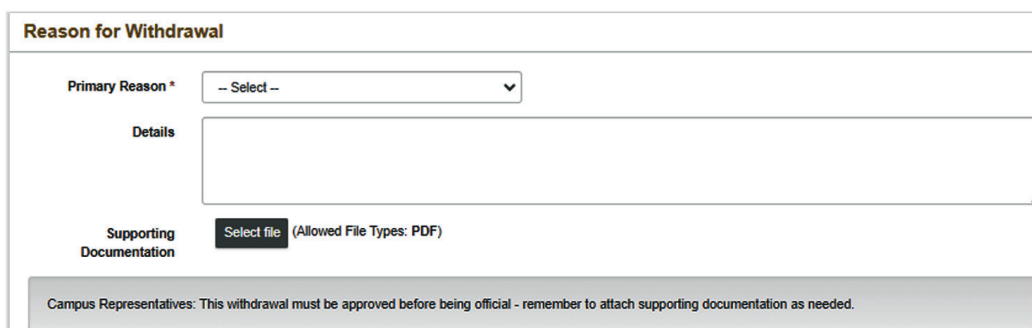
- Are there categories (learner characteristics, external factors, internal factors, or student expectations) that predominate for STEM withdrawal reasons?
- What proportion of these withdrawal reasons offer opportunities for improved course persistence through either support or intervention?

This study contributes to the understanding of attrition in online STEM courses, making needed contributions to the reported empirical data, particularly in areas including external and environmental factors. There has been noted variability in operationalizing external and environmental factors with limited reliability and validity reported (Heilporn & Lakhali, 2022), justifying additional works to understand these nuanced withdrawal reasons in online courses. Understanding withdrawal reasons can allow institutions to design effective interventions to address what is within their control and to design student support for reasons not within their control.

## **MATERIALS AND METHODS**

### ***Study Design***

This study was designed as a qualitative descriptive investigation (deductive thematic analysis) of the reasons students give to their advisors for withdrawing from selected STEM courses. Students can complete an online form (Figure 2) to request a course withdrawal; the open comment box is unnecessary. However, many work directly with their academic advisor via email, phone, or text to make the request. Academic advisors use that communication to process withdrawals using a single selection from the required dropdown list of codes, then add open-ended comments to detail withdraw-



**FIGURE 2**

*Information Prompt for Student-Initiated Withdrawal*

al reasons. The existing institutional codes for withdrawal reasons did not adequately capture the dimensions and elements in the theoretical framework (Figure 1). Hence, the research team processed the open-ended comments to categorize a more robust coding of withdrawal

reasons (Table 1) without referencing the institutionally provided codes.

The raw data was received from the Office of Strategy and Innovation and then anonymized by one co-PI before being given to the coders under the direction of the PI. This

**TABLE 1**

*Coding Chart for Student Withdrawal Reasons*

<i>Level 1</i>	<i>Code</i>	<i>Level 2</i>	<i>Code</i>
Administrative Reasons	ADMN	Registered for incorrect course	INCOR
		Course not needed for degree	NOTND
		Materials not received in time	MATRL
External/ Environmental	EXTNL	Funding	FUND
		Deployment	DEPLY
		Personal conflicts (e.g., schedule, family obligations)	PERSC
		Professional conflicts (e.g., career change, work schedule)	PROFC
		Lack of internet access	TECH
Internal Personal	INTL	Personal illness	MDCL
		Workload – Cognitive Load	WORK
		Change Major	CHANGE
		Delaying all progress	DELAY
		Engagement	ENGAGE
		Self-efficacy and motivation	MOTIV
Learner Characteristics/ Skills	LEARN	Goal commitment, resilience/grit	GOALS
		Prerequisites and Prior Knowledge	PRIOR
		Insufficient technical or computer skills	COMPTR
		Time Management	TIME

*(Table continues next page)*

**TABLE 1**  
(Continued)

<i>Level 1</i>	<i>Code</i>	<i>Level 2</i>	<i>Code</i>
Institutional Characteristics	ICHAR	Institutional Support	SUPPORT
		Program Quality	PROGRAM
		Negative impression of instructor	INSTR
		Lack of interaction with instructor	INTERACTION
		Lack of timely and constructive feedback	FEEDBACK
		Topics	TOPIC
		Course Design & Assignment Types	DESIGN
		Modality Preference	MODE
		Peer Interactions	PEER
		Dissatisfaction with course grade	GRADE
Not Enough Information	NONE		

study was deemed exempt by the institutional review board (Approval #22-080).

### **POPULATION, SAMPLE, AND DATA COLLECTION**

The population for this study was the total number of learners who withdrew from the target online STEM courses offered at a medium-sized private university in AY 2021-22 (Table 2 presents course information and enrollment data). Study data was anonymous;

thus, information about the withdrawn students was unavailable (e.g., grade, gender, age, etc.). Students enrolling in online courses are overwhelmingly non-traditional students: the average age is 31, and over half are affiliated with the military (heavily subsidized). The student body is predominately male (82%). The campus enrolls approximately 20,000 students each year.

For this study, a withdrawal was defined as a student who took administrative action to be removed from the course by their advisor. Course drops were not included in this study. A student can complete drops without adminis-

**TABLE 2**  
*STEM Courses Included in Study*

	<i>Course Name</i>	<i>Catalog Number</i>	<i>Enrolled at Term Start</i>
General Education	Introduction to Computers and Applications	CSCI 109	1456
	Introduction to Computing for Data Analysis	CSCI 123	510
	Basic Algebra & Trigonometry	MATH 106	997
	Exploration in Physics	PHYS 102	1373
	Science of Flight	PHYS 123	473
Degree Support	Introduction to Engineering	ENGR 101	417
	Introduction to Computing for Engineers	ENGR 115	301
	Statics	ESCI 201	264
	Pre-calculus for Aviation	MATH 111	1572
Total			7363

trative action by their academic advisor. Drops occur within the first four days of the course term. Course drops do not incur any financial penalty. Withdrawal may have financial penalties for students, depending on how the course was funded.

The courses selected for this study fell into general education and degree support categories. Each course is offered over a 9-week term through the Canvas learning management system, with various opportunities for multi-directional communication. Student-to-student interactions are supported in the courses through asynchronous discussion forums and Canvas messaging. Student-to-instructor interactions are supported asynchronously through the discussion forums and messaging or synchronously through EagleVision/Zoom office, telephone, or Microsoft Teams. Instructor-to-student interactions are supported through the same mechanisms as student-to-instructor interaction, with the addition of course announcements. A very small minority of these courses included a required weekly class meeting through EagleVision/Zoom. These courses were selected because they have a high volume of general education enrollment or are prerequisites for our largest degree programs.

### **Data Analysis**

Simple proportions were calculated in various combinations for comparing withdrawal rates and among the reasons given to advisors for withdrawing. Two inferential techniques were applied to verify the reasonability of our conclusions as if this were a sample from all withdrawals from these courses in the near future (Motulsky, 2017).

## **RESULTS**

The descriptive investigations focused on three perspectives of the data: (1) rates of withdrawal by individual course, the two categories of courses (general education versus

degree support), and by STEM discipline, (2) predominant broad withdrawal reasons from online STEM courses (Level 1 codes in Table 1), and (3) the more nuanced distribution of withdrawal reasons (Level 2 codes in Table 1). By answering these questions, we can better understand which online STEM courses have notable persistence problems and what the motivations for withdrawal are, allowing for the design of effective interventions and supports.

### **Rates of Withdrawal in Online STEM Courses**

Beginning at the most macro level of understanding student withdrawal reasons, the total enrollments of the target courses were retrieved from the Student Information System (SIS) for the target courses in the 2021–2022 academic year (Table 2). While the withdrawal rates (Table 3) are each below 10%, understanding the reasons that 251 times (3.41% of all enrollments in the target courses) a student did not persist is important for faculty and administrators of the studied institution.

The course with the highest per-course withdrawal rate (9.6%) is Introduction to Computing for Engineers (ENGR 115), accounting for 11.6% of all withdrawals from the target courses (n=251). The course with the lowest per-course withdrawal rate (2%) is Basic Algebra and Trigonometry (MATH 106), which accounts for just 8% of all withdrawals. The collective withdrawal rate from all courses evaluated in this study is 3.41%.

The withdrawal rate has a noticeable spread between general education STEM courses (59.0%, n=148) and degree support STEM courses (41.0%, n=103). A z-test of two proportions supports the assumption that no difference exists between withdrawal rates in courses for general education and those for degree support (p=0.37).

The withdrawal rate across disciplines was consistent, with physics seeing 27% (n=69) of withdrawals, mathematics with 24% (n=61) withdrawals, technology also showing 24% (n=59) of withdrawals, and engineering with

**TABLE 3**  
*Withdrawal Data by Target Course*

Target Course	% Withdrawals per	
	Course	Withdrawal (n)
ENGR 115	9.6	29
ENGR 101	5.5	23
CSCI 123	4.1	21
PHYS 123	4.0	19
ESCI 201	3.8	10
PHYS 102	3.6	50
CSCI 109	2.6	39
MATH 111	2.6	41
MATH 106	2.0	20
Overall	3.41	251

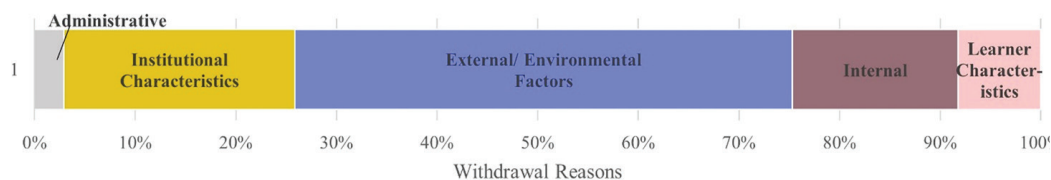
the remaining 25% (n=62), for a total of 251 withdrawals in the study time frame from the courses evaluated. The goodness-of-fit test was used to analyze the proportions of withdrawals in the four disciplines the target courses fall into. The test result gave a high p-value of 0.824, which confirms that each of the four disciplines will contribute to about a quarter of all withdrawals within the studied courses.

**Broad Reasons for Online STEM Course Withdrawal**

Academic advisors processing the students’ withdrawal requests documented the reasons for withdrawal in this study. As previously mentioned, the existing withdrawal codes used by advisors need to adequately capture the breadth of withdrawal reasons, even at the broader level. Furthermore, some of the ex-

isting codes could cover more than one of the broad withdrawal reasons. This necessitated using open-ended comments for researchers to identify a withdrawal reason appropriately. However, some advisors either did not provide comments or the comments were not useful in coding (e.g., referencing an attachment that is not included in the system-generated report). For this reason, the total number of withdrawals analyzed for withdrawal reasons was reduced from 251 to 170.

The breakdown of the predominant broad categories for withdrawal from online STEM courses in this study is presented in Figure 3. Administrative withdrawal reasons only accounted for 3% of withdrawals (n=5). Institutional characteristics accounted for 23% of withdrawals (n=39). External and environmental factors accounted for 49% (n=84), internal factors accounted for 16% (n=28), and learner



**FIGURE 3**  
*Withdrawal Reasons From Online STEM Courses (Level 1)*

characteristics represented 8% (n=14). This trend holds when evaluating primary withdrawal reasons when courses are grouped by general education versus degree support. The number of withdrawals in discipline groups within this data is too small to analyze but will be investigated with a larger data set in the future.

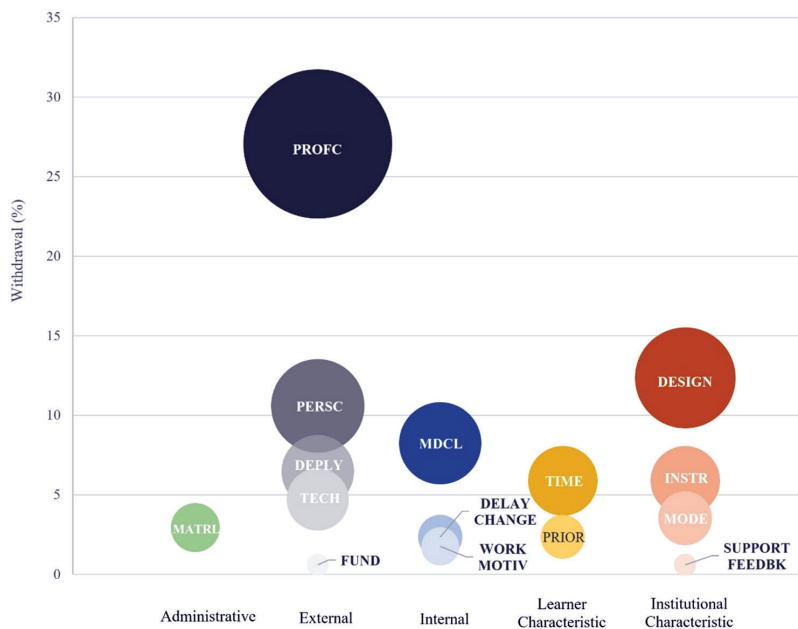
### *Nuanced Reasons for Online STEM Course Withdrawal*

The distribution of nuanced withdrawal reasons from online STEM courses is presented in Figure 4. The level one coding category of external withdrawal reasons constituted the most significant portion of withdrawal reasons. However, within this category (n=84), the level two category of professional conflicts was the most prevalent reason, representing 55% of the withdrawals in this category. Professional conflicts include career change and work-related travel. Personal conflicts were also a predominant withdrawal reason within this level

one category, constituting another 21% of withdrawals in this category. Personal conflicts include a family emergency or illness (not the student) and personal schedule challenges like childcare. The remaining withdrawals in this category were deployment (13%), technology access (10%), and funding (1%).

Institutional characteristics comprised the next largest category of withdrawal reasons (n=39), with the predominant, more nuanced category being designed at 54% of withdrawals in this level one category. Design includes learning environment design and assignment types. The most prominent reason within this category was the instructor, at 26%. Modality accounted for 15% of withdrawals in the institutional characteristics category, followed by support and feedback at 3% each, with grade, interaction, peers, program, and course topics not selected as withdrawal reasons.

Of students who withdrew for internal reasons (n=28), 50% withdrew for personal medical reasons while delaying degree progress



**FIGURE 4**

*Withdrawal Reasons From Online STEM Courses (Level 2)*

and changing central, accounting for 14% of the withdrawals in this category. Motivation and cognitive overload represented 11% of withdrawal reasons in this category. Engagement and goals were not selected as reasons for withdrawal in this category.

Learner characteristics ( $n=14$ ) represented some of the total withdrawals, with time management representing 71% of withdrawals in this category. Inadequate prerequisite knowledge accounted for 29% of withdrawals in this category, while no students reported insufficient technical or computer skills as a withdrawal reason.

Significantly, few students withdrew because of administrative reasons ( $n=5$ ), but those that did withdrew because their course materials were not received on time. No students indicated they withdrew because of registering for the incorrect course or because it was not needed for their degree. Those were not likely captured because this study evaluated withdrawals, not drops. Students who left the course within the first four days were categorized as a drop. A student would likely leave the course during this window of time due to these reasons.

While it would be interesting to explore whether the predominant withdrawal reasons persist with less data aggregation, exploring sub-sets of data for general education versus degree support courses, the use of inferential analysis of these data for verification (Motulsky, 2017) is impeded by empty cells, whether they are grouped by discipline or by general education versus degree support.

## DISCUSSION

### Gateway Courses

While research literature on the topic within the last five years is scarce, some studies report withdrawal rates from online STEM courses. Studies on persistence in online biology coursework reported withdrawal rates ranging

from 9.0% to 16.5% (Mead et al., 2020; Scott, 2020). One study reported withdrawal rates from online calculus at 17.4% and a concerning 28.3% from online pre-calculus courses (Ferguson, 2020). Online engineering courses have reported withdrawal rates ranging from 12 – 13% (Zabihian, 2020). Withdrawal from asynchronous online chemistry courses has been reported to range from 4.6%–4.9% (Author) and 20–25% in asynchronous online laboratory courses (Mojica & Upmacis, 2022). Our average withdrawal rate in this study, aggregated from various STEM disciplines, was lower than the rates reported in the literature. The studies above did not present withdrawal data from multiple disciplines, and the data was drawn from different institutions under different conditions, so it is impossible to evaluate if there was a consistent withdrawal rate across subject areas. Our study finds that differences in withdrawal rate from online courses were not seen among STEM disciplines nor between general education STEM courses versus degree support STEM courses.

Understanding these patterns is essential in identifying *gateway courses*, which are credit-bearing, lower-division courses that develop vital foundational knowledge for which many students are at risk of failure and can thus be a barricade to further degree progress. Failure to complete a gateway course can slow degree progress (Sargent et al., 2022). While failure rate should also be evaluated when identifying a gateway course, the results of our study indicate that Introduction to Computer for Engineers (ENGR 115) warrants further investigation, with the highest withdrawal rate in the study at 9.6%. Students likely need a path around it because this is a degree-support course rather than general education. Failure to complete the course successfully could impact their degree path and timeline, as Sargent et al. (2022) suggested. Identifying online STEM courses with low persistence is important, but it is also important to know *why* students are unsuccessful in completing these courses. This allows for planning a framework of support for withdrawal reasons beyond the institution's

control and interventions to address withdrawal reasons within their control.

### ***Identifying Potential Foci for Intervention***

Some student withdrawal reasons are challenging to address or simply not addressable. In this study, the level one code of external and environmental factors accounted for most of the reasons for withdrawal. Professional conflict was the prevalent nuanced reason for these external and environmental factors, accounting for 55% of external/environmental withdrawals. Issues like career change, promotion, and work schedule change are not likely something the institution can readily offer support for beyond deadline flexibility or extended time to complete a course through an incomplete. Personal conflicts, which accounted for 21% of external/environmental withdrawals like child or elder care responsibilities or a family emergency, are also challenging for intervention beyond instructors offering deadline flexibility. Similarly, deployment, which constitutes 13% of external/environmental withdrawals, must be more amenable to institutional intervention to retain a student in an online STEM course for a given term. However, one study suggested that instructor communication and flexibility could affect course completion for deployed students (Trettin, 2017).

Internal and personal reasons accounted for the third most prevalent Level 1 withdrawal code. Like many withdrawal reasons in the external and environmental category, addressing them by the instruction or institution may be challenging. Within this category, half of the withdrawals were due to personal medical reasons, which could be supported through instructor deadline flexibility, incompletes, and offering a medical withdrawal. Some students may delay all degree progress to accommodate various factors in their lives. Furthermore, some students may either decide that a particular degree program does not suit them, or they may be drawn into a field, switching their major or minor course of study, and thus with-

drawing from an online STEM course that no longer fits their academic roadmap.

Student support that may be aimed at these harder-to-reach external and internal factors include an online orientation, freshman seminar, or curricular construct in the general education framework to address topics like finding or building a support network online and in person. These supports could also address some of the nuanced withdrawal reasons within the Level 1 code of Learner Characteristics, building time management skills (Hart, 2012; Ivankova & Stick, 2006; Pierrakeas et al., 2004; Stanford, 2008), computer skills (Dupin-Bryant, 2004; Harrell & Bower, 2011), self-efficacy, self-discipline, and self-motivation (Hart, 2012; Ivankova & Stick, 2006; Moore, 2014; Park & Choi, 2009). Student advising could also be leveraged to improve persistence in online STEM courses. Data shows that persistence in online courses is a function of the number of credit hours currently enrolled, with higher credit hours leading to stronger persistence (Aragon & Johnson, 2008). However, this finding should be viewed through the lens of cognitive load as a factor in online course withdrawal (Tyler-Smith, 2006), and there is likely a logistic curve in the relationship between credit hours and persistence. Many institutions have administrative caps on credit hour enrollments per term. The most direct area for intervention is within institutional characteristics, which, in this study, was the second largest Level 1 withdrawal code. Of the predominant withdrawal reasons here, instructor quality (26% of institutional characteristics withdrawals) and course design (54% of institutional characteristics withdrawals) were the largest. Course design is a noted persistence factor in STEM courses (Li et al., 2022). Recent research literature highlights the efficacy of targeted course design interventions on student outcomes, including course persistence (Hollowell et al., 2017). However, course design changes to improve retention as an isolated strategy are likely less impactful on persistence (Monteiro, 2017). Other studies have similarly noted that interventions and

supports in isolation may not be effective, noting that faculty professional development and coaching to improve student time management skills – may not achieve the desired learner outcomes (Mayled et al., 2019; Tabuenca et al., 2022). An institutional action to address online STEM course persistence should address multiple withdrawal reasons and with careful consideration of the complex problem of course persistence. However, from a research perspective, it will be challenging to disambiguate the efficacy of individual interventions or supports.

Research on supports and interventions is challenging to evaluate. Even a review article that explored the efficacy of interventions in online settings included multiple studies that focused on traditional in-person interventions and only reported online interventions from four studies, with participant numbers ranging from tens to tens of thousands and durations of interventions lasting from one informal interaction to year-long undertakings (Delnoji et al., 2020). Furthermore, much of the work did not include a control. For these reasons, there is notably limited generalizability and validity, and more work is certainly justified in evaluating the efficacy of interventions and supports to improve course persistence. With such limited data for the broad category of online learning, understandably, there is a dearth of information specifically focused on online STEM course persistence interventions. However, the existing research on course persistence interventions can be used as a foundation to investigate potential future studies. With this in mind, based on a 2020 review article, targets for intervention based on *modifiable predictors of noncompletion* are study and learning strategies and skills, academic self-efficacy, academic goals, and intentions (Delnoij et al., 2020). The authors report the most substantial evidence for online course completion interventions of coaching, remedial teaching, and peer mentoring (Delnoji et al., 2020). There is currently scarce alignment between the significant predictors of noncompletion and the design of course persistence intervention

efforts (Delnoji et al., 2020). This study is a critical step in that direction, first establishing nuance in the reasons for withdrawal and identifying areas for developing interventions and supports. Future work by the authors will contribute a much-needed investigation that is grounded in an alignment between the intervention and the factors that can be addressed by either the institution or the instructor.

Because nuance may be lost in the aggregate, practitioners, and administrators may want to evaluate detailed withdrawal reasons on a course-by-course basis to identify potentially effective targets for intervention and support. For example, in this study, the general education course Introduction to Computing for Data Analysis (CSCI 123) had a notable attrition rate (4.1%). In comparison, the degree support course with the highest attrition in this study was Introduction to Computing for Engineers (ENGR 115) (9.6% withdrawal rate). In both courses, most withdrawals fell within the Level 1 code of external factors, with more than half of the nuanced withdrawal reasons (Level 2 codes) being military deployment, personal conflicts, professional conflicts, or lack of internet access. Coaching is an intervention that could teach students strategies for balancing the responsibilities and impacts of external and environmental factors so that they can achieve their academic goals. However, from here, the two courses diverge. For CSCI 123, the second most prevalent Level 1 code was internal/personal, with nuanced codes of change of degree, delay of progress, or personal illness. By contrast, ENGR 115's second largest Level 1 code was institutional characteristics and nuanced code design, feedback, and instructor. More investigation is needed to explore the potential impacts of peer mentoring, coaching, or remedial teaching on persistence in these courses.

### **Limitations**

One of the most significant limitations of this study was the data loss due to the inability to code all withdrawal reasons accurately. Un-

fortunately, 32.3% of the withdrawals in this study could not be analyzed for a withdrawal reason. The researchers attempted to refine the withdrawal coding used by the academic advisors, but there were multiple administrative barriers to adjusting this procedure. Next, the researchers worked with the academic advising team to discuss the importance of using the comments to document more nuanced reasons for withdrawal and to communicate that attachments were lost in report generation. While these efforts did allow the researchers to arrive at the current data set, understandably, improvements could be made to reduce this data loss. Because the data loss was not associated with a particular course, student, or withdrawal reason, it is unlikely to have significantly influenced the results.

Another limitation of this study was selection bias. The researchers identified specific online undergraduate STEM courses in general education and degree support. However, this is only a partial analysis of all the courses at the institution that could have been evaluated. The selection of these courses could have influenced the results through selection bias.

Furthermore, the data used in this study was obtained for a defined period. It is possible that a longer-term study could show variations in these trends, particularly underscored by the rapid changes in higher education that were seen during and in the wake of the COVID-19 pandemic.

Demographic and learner characteristics have been linked to persistence in online STEM courses, with variable conclusions, as explored in the literature review. This study looked at anonymized data and thus cannot conclude the influence of these variables on persistence. Future work in this area should include demographics to ensure that nuances in persistence are preserved in aggregation.

## **CONCLUSION**

Understanding why students withdraw from online undergraduate STEM courses is cru-

cial for faculty and administrators of higher education institutions. This study noted that the withdrawal rate was lower than other recently reported values. This study presents an interesting finding not previously reported for online STEM courses. The withdrawal rates between general education STEM courses and degree support STEM courses were similar, as were withdrawal rates between STEM disciplines. If there were a difference, it might suggest that resources and supports should be allocated differently to bolster student success. If withdrawal rates were higher in degree-support STEM courses, it could indicate that degree-support STEM courses are more demanding, indicating students may struggle with specialized content and expectations within their chosen STEM degree programs, are not adequately prepared for the courses, or do not have adequate resources like tutoring or mentoring tailored to the needs of STEM majors. If withdrawal rates were higher in general education STEM courses, it could suggest that curriculum relevance is weak and raise questions about the content and teaching methods used to motivate, engage, and retain students. It would also be essential to evaluate resource allocation.

This study sought to identify withdrawal reasons that could be targeted for intervention and support. However, the data showed that withdrawal reasons predominantly fell into categories not readily addressable through support or intervention. The data shows potential areas to address, including support to develop learner time management skills and interventions to address instructor quality and course design. With this methodology for categorizing withdrawal reasons, the nuanced impact of support or intervention can be evaluated. The reasons for withdrawal explored in this study are not exclusive to online learners, and this approach could be applied to withdrawal from traditional in-person STEM courses. However, it is essential to consider how the modalities differ. For example, online courses often use course templates, with many instructors operating from the same course shell. In contrast,

in-person instructors are primarily responsible for generating their content. The interventions and supports to address persistence would inevitably vary between these populations.

### Declarations

The Institutional Review Board at Embry-Riddle Aeronautical University granted ethical approval for this study. The authors have no conflicts of interest to declare.

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### REFERENCES

- Angelino, L. M., Williams, F. K., & Natvig, D. (2007). Strategies to engage online students and reduce attrition rates. *Journal of Educators Online*, 4(2). <https://eric.ed.gov/?id=EJ907749>
- Aragon, S. R., & Johnson, E. S. (2008). Factors influencing completion and noncompletion of community college online courses. *The American Journal of Distance Education*, 22(3), 146–158. <https://doi.org/10.1080/08923640802239962>
- Atchley, T. W., Wingenbach, G., & Akers, C. (2013). Comparison of course completion and student performance through online and traditional courses. *The International Review of Research in Open and Distributed Learning*, 14(4), 104–116. <https://doi.org/10.19173/irrodl.v14i4.1461>
- Bandura, A. (2002). Social cognitive theory in cultural context. *Applied Psychology*, 51(2), 269–290. <https://doi.org/10.1111/1464-0597.00092>
- Bean, J. P. (1990). Why students leave: Insights from research. In D. Hossler & J. P. Bean (Eds.), *The Strategic Management of College Enrollments* (pp. 170–185). Jossey-Bass.
- Burch, J. J. C. (2018). *An application of Tinto's Student Integration Model and Bandura's Social Cognitive Theory to student retention in STEM disciplines*. (Doctoral Dissertation, Tarleton State University). <https://www.proquest.com/docview/2040105928/abstract/79D-DC7448A984F27PQ/1>
- Castleman, B. L., Long, B. T., & Mabel, Z. (2018). Can financial aid help address the growing need for STEM education? The effects of needs-based grants on the completion of science, technology, engineering, and math courses and degrees. *Journal of Policy Analysis and Management*, 37(1), 136–166. <https://doi.org/10.1002/pam.22039>
- Castles, J. (2004). Persistence and the adult learner: Factors affecting persistence in open university students. *Active Learning in Higher Education*, 5(2), 166–179. <https://doi.org/10.1177/1469787404043813>
- Cochran, J., Campbell, S. M., Baker, H. M., & Leeds, E. M. (2014). The role of student characteristics in predicting retention in online courses. *Research in Higher Education*, 55(1), 27–48. <https://doi.org/10.1007/s11162-013-9305-8>
- Cottrell, R. S. (2021). Student performance in online classes at a Hispanic-serving institution: A study of the impact of student characteristics in online learning. *Online Learning Journal*, 25(3), 18–35. <https://doi.org/10.24059/olj.v25i3.2853>
- Delnoji, L. E. C., Dirkx, K. J. H., Janssen, J. P. W., & Martens, R. L. (2020). Predicting and resolving noncompletion in higher (online) education – A literature review. *Educational Research Review*, 29, 1–17. <https://doi.org/10.1016/j.edurev.2020.100313>
- Drouin, M. A. (2008). The relationship between students' perceived sense of community and satisfaction, achievement, and retention in an online course. *Quarterly Review of Distance Education*, 9(3), 267. Retrieved from [https://erau.primo.exlibrisgroup.com/permalink/01ERAU\\_IN-ST/19h1c1a/cdi\\_proquest\\_journals\\_231179836](https://erau.primo.exlibrisgroup.com/permalink/01ERAU_IN-ST/19h1c1a/cdi_proquest_journals_231179836)
- Dupin-Bryant, P. (2004). Pre-entry variables related to retention in online distance education. *American Journal of Distance Education*, 18(4), 199–206. [https://doi.org/10.1207/s15389286ajde1804\\_2](https://doi.org/10.1207/s15389286ajde1804_2)
- Faulconer, E., Griffith, J., Wood, B., Acharyya, S., & Roberts, D. (2018). A comparison of online, video synchronous, and traditional learning modes for an introductory undergraduate physics course. *Journal of Science Education and Technology*, 27, 404–411. <https://doi.org/10.1007/s10956-018-9732-6>
- Ferguson, S. (2020). Attrition in online and face-to-face calculus and pre-calculus courses: A comparative analysis. *Journal of Educators Online*, 17(1). <https://eric.ed.gov/?id=EJ1241557>

- Finnegan, C., Morris, L. V., & Lee, K. (2008). Differences by course discipline on student behavior, persistence, and achievement in online courses of undergraduate general education. *Journal of College Student Retention: Research, Theory & Practice*, 10(1), 39–54. <https://doi.org/10.2190/CS.10.1.d>
- Flood, J. (2002). Read all about it: Online learning facing 80% attrition rates. *Turkish Online Journal of Distance Education*, 3(2), 1–4. Retrieved from <https://dergipark.org.tr/en/pub/tojde/issue/16940/176853>
- Harrell, I. L., & Bower, B. L. (2011). Student characteristics that predict persistence in community college online courses. *American Journal of Distance Education*, 25(3), 178–191. <https://doi.org/10.1080/08923647.2011.590107>
- Hart, C. (2012). Factors associated with student persistence in an online program of study: A review of the literature. *Journal of Interactive Online Learning*, 11(1), 19–42. Retrieved from <https://www.ncolr.org/issues/jiol/v11/n1/factors-associated-with-student-persistence-in-an-online-program-of-study-a-review-of-the-literature.html>
- Heilporn, G., & Lakhali, S. (2021). Environmental facilitators and barriers to student persistence in online courses: Reliability and validity of new scales. *Journal of Continuing Higher Education*, 70(1), 1–20. <https://doi.org/10.1080/07377363.2020.1847972>
- Herbert, M. (2006). Staying the course: A study in online student satisfaction and retention. *Online Journal of Distance Learning Administration*, 94(4), 300–317. Retrieved from <https://ojdla.com/archive/winter94/herbert94.pdf>
- Hollowell, G. P., Brooks, R. M., & Anderson, Y. B. (2017). Course design, quality matters, training, and student outcomes. *American Journal of Distance Education*, 31(3), 207–216. <https://doi.org/10.1080/08923647.2017.1301144>
- Huntington-Klein, N., Cowan, J., & Goldhaber, D. (2017). Selection into online community college courses and their effects on persistence. *Research in Higher Education*, 58, 244–269. <https://doi.org/10.1007/s11162-016-9425-z>
- Ivankova, N. V., & Stick, S. L. (2006). Students' persistence in a distributed doctoral program in educational leadership in higher education: A mixed methods study. *Research in Higher Education*, 48(1), 93–135. <https://doi.org/10.1007/s11162-006-9025-4>
- Jaggars, S. S. (2014). Choosing between online and face-to-face courses: Community college student voices. *The American Journal of Distance Education*, 28(1), 27–38. <https://doi.org/10.1080/08923647.2014.867697>
- Jaggars, S. S., Edgecombe, N., & Stacey, G. W. (2013). What we know about online course outcomes. In *Online Education and Instructional Technology*. Community College Research Center. Retrieved from <http://ccrc.tc.columbia.edu/publications/what-we-know-online-course-outcomes.html>
- Joyner, S. A., Fuller, M. B., Holzweiss, P. C., Henderson, S., & Young, R. (2014). The importance of student-instructor connections in graduate-level online courses. *MERLOT Journal of Online Learning and Teaching*, 10(3), 436–445. Retrieved from [https://jolt.merlot.org/Vol10\\_No3.htm](https://jolt.merlot.org/Vol10_No3.htm)
- Kember, D. (1995). *Open learning courses for adults: A model of student progress*. New Jersey: Educational Technologies.
- Kember, D., & Fan, S. (2023). Review of literature on attrition. In *Adapting to Online and Blended Learning in Higher Education*, 157–173. Springer, Singapore. [https://doi.org/10.1007/978-981-99-0898-1\\_9](https://doi.org/10.1007/978-981-99-0898-1_9)
- Kember, D., Trimble, A., & Fan, S. (2022). An investigation of the forms of support needed to promote the retention and success of online students. *American Journal of Distance Education*, 37(3), 169–184. <https://doi.org/10.1080/08923647.2022.2061235>
- Kinsey, A. W. (2022). *The relationship of cognitive load and motivation as a predictor of persistence in accelerated online asynchronous courses* (Doctoral dissertation, The University of Memphis). Retrieved from <https://www.proquest.com/docview/2659282680?pq-origsite=gscholar&fromopenview=true>
- Kittur, J., Brunhaver, S. R., Bekki, J. M., & Lee, E. (2021, January). Role of course and individual characteristics in the course-level persistence intentions of online undergraduate engineering students: A path analysis. In *REES AEEE 2021 Conference: Engineering Education Research Capability Development*. Perth, WA: Engineers Australia. Retrieved from <https://www.proceedings.com/066488-0036.html>
- Kittur, J., Brunhaver, S. R., Bekki, J.M., & Lee, E. (2021, July). Examining the impact of interpersonal interactions on course-level persistence intentions among online undergraduate engineering students. In *American Society for Engineering Education Annual*

- Conference. Retrieved from <https://peer.asee.org/examining-the-impact-of-interpersonal-interactions-on-course-level-persistence-intentions-among-online-undergraduate-engineering-students.pdf>
- Lee, Y., & Choi, J. (2011). A review of online course dropout research: Implications for practice and future research. *Educational Technology Research and Development*, 59(5), 593–618. <https://doi.org/10.1007/s11423-010-9177-y>
- Lee, Y., Choi, J., & Kim, T. (2012). Discriminating factors between completers of and dropouts from online learning courses. *British Journal of Educational Technology*, 44(2), 328–337. <https://doi.org/10.1111/j.1467-8535.2012.01306.x>
- Lee, E., Pate, J. A., & Cozart, D. (2015). Autonomy support for online students. *TechTrends*, 59, 54–61. <https://doi.org/10.1007/s11528-015-0871-9>
- Levy, Y. (2007). Comparing dropouts and persistence in e-learning courses. *Computers & Education*, 48(2), 185–204. <https://doi.org/10.1016/j.compedu.2004.12.004>
- Li, C., Herbert, N., Yeom, S., & Montgomery, J. (2022). Retention factors in STEM education Identified using learning analytics: A systematic review. *Education Sciences*, 12(11), 1–18. <https://doi.org/10.3390/educsci12110781>
- Liu, S., Gomez, J., & Yen, C.-J. (2009). Community college online course retention and final grade: Predictability of social presence. *Journal of Interactive Online Learning*, 8(2), 165–182. Retrieved from [https://digitalcommons.odu.edu/efl\\_fac\\_pubs/10/](https://digitalcommons.odu.edu/efl_fac_pubs/10/)
- Lou, Y., Bernard, R. M., & Abrami, P. C. (2006). Media and pedagogy in undergraduate distance education: A theory-based meta-analysis of empirical literature. *Educational Technology Research and Development*, 54(2), 141–176. <https://doi.org/10.1007/s11423-006-8252-x>
- Martinez-Carrascal, J.A., & Sancho-Vinuesa, T. (2021, June). Does failing the first assessment affect withdrawal decisions at course level? Empirical evidence. *Learning Analytics Summer Institute*, Spain. Retrieved from <http://ceur-ws.org/Vol-3029/paper01.pdf>
- Mayled, L. H., Ross, L., Krause, S. J., Judson, E., Middleton, J. A., Culbertson, R. J., Hjelmstad, K. L., Hjelmstad, K. D., & Glassmeyer, K. (2019, June 15). Impact of evidence-based active learning faculty development on low-SES engineering students' achievement. 2019 ASEE Annual Conference & Exposition. <https://peer.asee.org/impact-of-evidence-based-active-learning-faculty-development-on-low-ses-engineering-students-achievement>
- McKinney, L., Novak, H., Hagerdorn, L. S., & Luna-Torres, M. (2018). Giving up on a course: An analysis of course dropping behaviors among community college students. *Research in Higher Education*, 60(2), 1–19. <https://doi.org/10.1007/s11162-018-9509-z>
- Mead, C., Supriya, K., Zheng, Y., Anbar, A. D., Collins, J. P., LePore, P., & Brownell, S. E. (2020). Online biology degree program broadens access for women, first-generation to college, and low-income students, but grade disparities remain. *PLOS ONE*, 15(12), e0243916. <https://doi.org/10.1371/journal.pone.0243916>
- Mojica, E. R. E., & Upmacis, R. K. (2021). Challenges encountered and students' reactions to practices utilized in a general chemistry laboratory course during the COVID-19 pandemic. *Journal of Chemical Education*, 99(2), 1053–1059. <https://doi.org/10.1021/acs.jchemed.1c0083>
- Monteiro, S. J. de A. (2017). *Course design in e-Learning and the relationship with attrition and dropout: A systematic review* (Doctoral Dissertation, University of Minho). <http://repositorium.sdum.uminho.pt/>
- Moore, J. (2014). Effects of online interaction and instructor presence on students' satisfaction and success with online undergraduate public relations courses. *Journalism & Mass Communication Educator*, 69(3), 271–288. <https://doi.org/10.1177/1077695814536398>
- Morris, L. V., Wu, S.-S., & Finnegan, C. L. (2005). Predicting retention in online general education courses. *American Journal of Distance Education*, 19(1), 23–36. [https://doi.org/10.1207/s15389286ajde1901\\_3](https://doi.org/10.1207/s15389286ajde1901_3)
- Motulsky, H. (2017). *Intuitive biostatistics* (4th ed.). Oxford University Press. <https://global.oup.com/ushe/product/intuitive-biostatistics-9780190643560>
- Muljana, P. S. & Luo, T. (2019). Factors contributing to student retention in online learning and recommended strategies for improvement: A systematic literature review. *Journal of Information Technology Education: Research*, 18, 19–57. <https://doi.org/10.28945/4182>
- Murphy, C. A., & Stewart, J. C. (2017). On-campus students taking online courses: Factors associated with unsuccessful course completion. *Internet and Higher Education*, 34, 1–9. <https://doi.org/10.1016/j.iheduc.2017.03.001>

- Ojokheta, K. (2010). A path-analytic study of some correlates predicting persistence and student's success in distance education in Nigeria. *Turkish Online Journal of Distance Education*, 11(1). Retrieved from <https://dergipark.org.tr/en/pub/tojde/issue/16907/176322>
- O'Neill, L. D., Wallstedt, B., Eika, B., & Hartvigsen, J. (2011). Factors associated with dropout in medical education: A literature review. *Medical Education*, 45(5), 440-454. <https://doi.org/10.1111/j.1365-2923.2010.03898.x>
- Packham, G., Jones, P., Miller, C., & Thomas, B. (2004). E-learning and retention: Key factors influencing student withdrawal. *Education & Training*, 46(6/7), 335-342. <https://doi.org/10.1108/00400910410555240>
- Park, J. H., & Choi, H. J. (2009). Factors influencing adult learners' decision to drop out or persist in online learning. *Educational Technology & Society*, 12(4), 207-217. Retrieved from [https://erau.primo.exlibrisgroup.com/permalink/01ERAU\\_INST/19h1c1a/cdi\\_proquest\\_journals\\_2139084226](https://erau.primo.exlibrisgroup.com/permalink/01ERAU_INST/19h1c1a/cdi_proquest_journals_2139084226)
- Pedraza, L., & Chen, R. (2022). Examining motivator factors of STEM undergraduate persistence through two-factor theory. *The Journal of Higher Education*, 93(4), 532-558. <https://doi.org/10.1080/00221546.2021.1999722>
- Pierrakeas, C., Xenos, M., Panagiotakopoulos, C., & Vergidis, D. (2004). A comparative study of dropout rates and causes for two different distance education courses. *International Review of Research in Open and Distributed Learning*, 5(2), 1-15. <https://doi.org/10.19173/irrodl.v5i2.183>
- Pigliapoco, E., & Bogliolo, A. (2008). The effects of psychological sense of community in online and face-to-face academic courses. *International Journal of Emerging Technologies in Learning*, 3(4), 60-69. Retrieved from <https://www.learn-techlib.org/p/45021/>
- Roubides, P. (2016). *Self-regulation as a predictor of successful completion of an accelerated online OER college mathematics course* (Doctoral dissertation, Keiser University). Retrieved from <https://www.proquest.com/docview/1785396185?pq-origsite=gscholar&fromopenview=true>
- Rovai, A. P. (2003). In search of higher persistence rates in distance education online programs. *Internet and Higher Education*, 6(1), 1-16. [https://doi.org/10.1016/S1096-7516\(02\)00158-6](https://doi.org/10.1016/S1096-7516(02)00158-6)
- Sargent, C. S., Sullivan, T., & McAlum, H. (2022). DFW in gateway courses not always a graduation problem: A study in Intermediate Accounting I from 2007 to 2018. *Journal of Accounting Education*, 60. <https://doi.org/10.1016/j.jaccedu.2022.100795>
- Scott, J. (2020). *Student success of online vs. in-person biology courses at Virginia community colleges*. (Doctoral Dissertation, Liberty University). Retrieved from <https://digitalcommons.liberty.edu/doctoral/2779>
- Sinclair, E. (2017). A case study on the importance of peer support for e-learners. *Proceedings of the 9th International Conference on Computer Supported Education*, pp. 280-284. <https://doi.org/10.5220/0006263602800284>
- Stanford, D. E. (2008). Persistence in online classes: A study of perceptions among community college stakeholders. *Journal of Online Teaching & Learning* 4(1), 37-50. Retrieved from [https://jolt.merlot.org/Vol4\\_No1.htm](https://jolt.merlot.org/Vol4_No1.htm)
- Suresh Kumar, S., & Mallikarjuna Shastry, P. M. (2019). Analysis of student engagement and course completion in massive open online courses. *Integrated Intelligent Computer, Communication and Security*, 447-458. Springer, Singapore. [https://doi.org/10.1007/978-981-10-8797-4\\_46](https://doi.org/10.1007/978-981-10-8797-4_46)
- Tabuenca, B., Greller, W., & Verpoorten, D. (2022). Mind the gap: Smoothing the transition to higher education fostering time management skills. *Universal Access In The Information Society*, 21(2), 367-379. <https://doi.org/10.1007/s10209-021-00833-z>
- Tinto, V. (1987). *Leaving College: Rethinking the causes and cures of student attrition*. The University of Chicago Press.
- Trettin, A. F. (2017). *Distance learning during combat deployment: A national exploratory study of factors affecting course completion*. (Doctoral dissertation, University of Toledo). Retrieved from [https://etd.ohiolink.edu/acprod/odb\\_etd\\_etd/r/1501/10?clear=10&p10\\_accession\\_num=toledo1492703865993093](https://etd.ohiolink.edu/acprod/odb_etd_etd/r/1501/10?clear=10&p10_accession_num=toledo1492703865993093)
- Tyler-Smith, K. (2006). Early attrition among first time elearners: A review of factors that contribute to dropout, withdrawal, and noncompletion rates of adult learners undertaking elearning programmes. *Journal of Online Learning and Teaching*, 2(2), 73-85. Retrieved from [https://jolt.merlot.org/Vol2\\_No2.htm](https://jolt.merlot.org/Vol2_No2.htm)
- Willging, P. A., & Johnson, S. D. (2009). Factors that influence students' decision to drop out of

- online courses. *Journal of Asynchronous Learning Networks*, 13(3), 115. Retrieved from <https://eric.ed.gov/?id=EJ862360>
- Wladis, C., Hachey, A. C., & Conway, K. (2015a). Which STEM majors enroll in online courses, and why should we care? The impact of ethnicity, gender, and non-traditional student characteristics. *Computers & Education*, 87, 285–308. <https://doi.org/10.1016/j.compedu.2015.06.010>
- Wladis, C., Hachey, A. C., & Conway, K. M. (2015b). The representation of minority, female, and non-traditional STEM majors in the online environment at community colleges: A nationally representative study. *Community College Review*, 43(1), 89–113. <https://doi.org/10.1177/0091552114555904>
- Xenos, M., Pierrakeas, C., & Pintelas, P. (2002). A survey on student dropout rates and dropout causes concerning the students in the Course of Informatics of the Hellenic Open University. *Computers & Education*, 39(4), 361–377. [https://doi.org/10.1016/S0360-1315\(02\)00072-6](https://doi.org/10.1016/S0360-1315(02)00072-6)
- Xu, D., & Jaggars, S. (2013). *Adaptability to online learning: Differences across types of students and academic subject areas* (Vol. 54). Community College Research Center. <https://files.eric.ed.gov/fulltext/ED539911.pdf>
- Zabihian, F. (2020, June). Teaching thermodynamics online: Instructor and student perspectives. *2020 ASEE Virtual Annual Conference*. Retrieved from <https://peer.asee.org/teaching-thermodynamics-online-instructor-and-student-perspectives>