Interaction-Oriented Instructional Practices Show Promise in Enhancing Overall Performance and Narrowing Racial Achievement Gaps in College Online Courses

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Abstract

This study examines the impact of interaction-oriented instructional practices on student performance and racial achievement gaps in college online courses. By linking survey data from almost 400 online instructors with student-level transcript records at a state community college system, we examine the relationship between six domains of interaction-oriented practices and student concurrent and downstream success outcomes. Our results reveal a strong positive association between the overall usage of interaction-oriented practices and course completion rates, where instructor–student course managerial interactions play a particularly critical role in narrowing racial performance gaps. These results highlight the potential for targeted instructional strategies to foster equitable outcomes in online education and provide actionable insights for practitioners to enhance engagement and inclusivity in digital learning environments.

Keywords: online learning, evidence-based teaching, course completion, higher education

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Introduction

Notable theories of online teaching and learning have converged on the crucial role effective interactions play in promoting student engagement, satisfaction, and success in a virtual learning environment (Anderson, 2004; Bolliger & Martin, 2018; Garrison et al., 2003; Moore, 1989). Mounting evidence consistently suggests that in semester-length online courses, where physical separation can lead to feelings of isolation and disengagement, effective interactions foster a sense of community and belonging among students, which is essential for maintaining motivation and engagement (e.g., Bork & Rucks–Ahidiana, 2013; Dixson, 2015; Garrison & Cleveland-Innes, 2005; Gherghel et al., 2023; Martin & Bolliger, 2018; Jaggars & Xu, 2016). Moreover, success in online learning requires a high level of self-regulation, time management, and digital literacy. Yet, students from under-resourced educational backgrounds may have had fewer opportunities to develop these skills (Jaggars & Xu, 2016; Martin et al., 2019). These students can particularly benefit from the structure and guidance provided through frequent and meaningful interactions with instructors (Glazier, 2016; Ladson-Billings, 1995; Bolliger & Martin, 2018), as well as collaborative activities through peer interactions (Alqurashi, 2019; Richardson et al., 2017). As a result, effective interactions have the potential to serve as a crucial mechanism for addressing equity gaps in online learning at open-access institutions, such as community colleges, which serve a large proportion of students from historically underrepresented groups (Jenkins & Fink, 2015; Ramos & Sifuentez, 2021).

Can interaction-oriented teaching practices lead to better student outcomes and reduce racial achievement gaps at open-access institutions? If so, are practices that promote certain types of interaction more helpful than others? Answers to these questions are fundamental to improving online learning and reducing equity gaps at scale. While a growing number of studies have explored and shown positive effects of interaction-oriented practices on student performance and engagement outcomes (e.g., Glazier, 2016; Johnson & Mejia, 2014; Wei et al., 2015), much of the existing evidence comes from small-scale studies conducted at four-year universities, which limits the applicability to open-access institutions. Nor does the current literature explicitly examine the potential of interaction-oriented practices to address learning gaps among historically marginalized groups.

This paper addresses these research gaps by collecting online instructors' use of interaction-oriented teaching practices through an NSF-funded survey of 369 online instructors in fall 2019 at a state community college system that includes almost two dozen institutions. The survey draws on a comprehensive person-purpose framework developed by Orona et al. (2022), which categorizes interaction-oriented practices in online learning into six sub-domains defined by the intersections between two dimensions: (i) the type of interaction that the instructional practice aims to promote (e.g., between peers or between instructors and students), as well as (ii) the pedagogical purpose of a given interaction (academic, social, managerial). We further link these practices with student course performance data that include close to 10,000 student course enrollment records to directly examine the empirical association between interaction-oriented practices and student course outcomes. Drawing on this unique dataset, we address the following research questions:

1. Can interaction-oriented teaching practices lead to better student course outcomes and reduce racial achievement gaps in community colleges?

2. Are interaction-oriented teaching practices associated with student subsequent college enrollment?

3. Are certain types of interaction-oriented practices more effective than others in promoting student course performance and subsequent college enrollment?

Our results reveal a strong positive correlation between overall usage of interaction-oriented practices and student course outcomes. Additional analyses that further break down practices into different domains based on the purpose of the interaction indicate that practices that aim to foster instructor–student course management interactions, student–student academic interactions, and student–student social interactions are particularly effective in promoting online course success. Additionally, instructor–student interactions regarding course management have a significant impact on reducing achievement gaps between underrepresented minority (URM) and non-URM students in the concurrent course and promote subsequent college persistence for both groups. While our sample includes courses prior to the COVID-19 pandemic and the online learning landscape may have evolved post-COVID-19, the foundational strategies for effective interaction identified in this study remain highly relevant. These findings provide a baseline for understanding and improving online teaching practices, offering evidence-based strategies that can be adapted to current and future online learning environments. As online education continues to be a significant component of higher education, these insights help educators develop and refine their approaches to enhance student engagement and success in the post-pandemic era.

Literature Review

Challenges Associated with Online Learning and Racial Achievement Gaps

Online learning has grown rapidly in higher education over the past two decades (Xu & Xu, 2020). Despite its expansion, there remains a strong need to improve its effectiveness. Research indicates that fully online courses often result in lower success rates compared to face-to-face courses at open-access institutions, including lower course completion, reduced likelihood of passing, and lower overall grades (Bettinger et al., 2017; Hart et al., 2018; Johnson & Mejia, 2014; Streich, 2014), as well as compromised downstream outcomes, such as increased course repetition and decreased college persistence (Bettinger et al., 2017; Hart et al., 2018; Huntington-Klein et al., 2017; Krieg & Henson, 2016; Shea & Bidjerano, 2018).

Several factors could contribute to the lower performance associated with online learning. One primary challenge is the greater difficulty in achieving effective interactions, which are crucial for student engagement and success (Moore et al., 2011). Researchers and practitioners consistently point out that effective interactions have a critical impact on student online learning process, satisfaction, and performance (Jaggars & Xu, 2016; Jung et al., 2002; Orona et al., 2022; Swan, 2002; Wanstreet, 2006). However, the physical separation inherent in online learning makes spontaneous interaction with peers and instructors difficult. This may not only hinder

students' ability to keep up with course requirements, but can also lead to feelings of isolation and disengagement (Bolliger & Martin, 2018).

While creating meaningful and effective interactions is beneficial to all online students, it is especially important for students from marginalized groups. These students often have limited opportunities to develop their time management skills. Thus, they can benefit greatly from the structure and guidance provided through frequent and meaningful interactions with instructors, which help them stay organized, understand expectations, and keep up with coursework (Bolliger & Martin, 2018; Glazier, 2016; Ladson-Billings, 1995). Moreover, students from marginalized groups often rely more heavily on a sense of community and peer support to navigate the academic challenges they face. Accordingly, insufficient opportunities to interact with peers and the lack of a sense of community in online learning environments can exacerbate feelings of loneliness and isolation among students from marginalized groups (Garrison & Cleveland-Innes, 2005; Tinto, 1993), which can lead to poorer academic outcomes (Garrison & Cleveland-Innes, 2005).

Indeed, current research consistently reveals that the performance gaps between students of different racial and socioeconomic backgrounds have widened in online learning environments (e.g., Johnson & Mejia, 2014; Xu & Jaggars, 2014). The performance decrements and exacerbated equity gaps associated with online learning were also commonly reported during the pandemic, suggesting that the challenges of fully online courses are likely to persist in the post-COVID era (e.g., Adnan & Anwar, 2020). A number of interview- and survey-based studies found that students who struggle in online courses consistently attribute a lack of connection with the instructor and peers as an important barrier to success (Bambara et al., 2009; Jaggars & Xu, 2016).

A Conceptual Framework for Interaction-oriented Practices in Online Instruction

In view of the critical role of interaction, much effort has been devoted to defining and understanding the various forms of interaction in an online learning environment. The literature has pointed out that online interaction is not unidimensional. In particular, existing research has described interaction in an online learning environment from two perspectives: the participants involved in the interaction and the instructional purpose served by the interaction. Below, we first summarize the literature for each perspective and then explain how they both contribute to the framework for capturing interaction-oriented practices in our study.

The first strand of research differentiates three types of interaction based on the participants involved in it, including student–instructor interaction, student–student interaction, and student–content interaction (e.g., Anderson, 2004; Bolliger & Martin, 2018; Moore, 1989; Wagner, 1998). For example, Moore's theory of online interaction, which is a predominant framework in distance education, suggests that student intellectual interaction with course content is a defining characteristic of education, as it results in changes in students' knowledge, perceptions, and skills. In addition, student–instructor interaction is essential for instructors to deliver course content, facilitate knowledge and skill acquisition, and provide additional support based on student needs. Finally, student–student interaction provides a valuable source of learning by promoting critical thinking and deepening students' understanding (Moore, 1989).

The second strand of literature, exemplified by the widely known community of inquiry (CoI) model, focuses on instructional goals served by interaction. Specifically, these frameworks suggest that online interaction serves three primary goals: academic, social, and managerial (Berge, 1995; Quality Matters, 2014; 2018). Academic interaction refers to activities where students construct meaning of the course content, which is critical for student learning of knowledge and skills. Social interaction refers to social exchanges among participants in the learning community, which allow them to be projected as "real people" and socially connected with each other. Managerial interaction refers to the organization and management of course expectations, policies, and details (e.g., deadlines).

Both strands of literature capture critical aspects of interaction in online learning, and prior studies have integrated both perspectives into more nuanced frameworks. For example, drawing on both lines of literature, Orona et al. (2022) proposed a person–purpose framework that categorizes interaction into six sub-domains defined by the intersections between the entities involved and the instructional goal. We draw on this framework and therefore explain each of the components in more detail below:

First, *instructor–student academic interaction (ISAI)* refers to instances where instructors communicate with students regarding the knowledge or skills to be learned in a course. Examples include an instructor answering content-related questions in synchronous sessions, discussion boards, and/or providing feedback on assignments. Second, *instructor–student social interaction (ISSI)* also happens between the instructor and the students, but instead focuses on social connections rather than the academic content. Third, *instructor–student course managerial interaction (ISCMI)* is when instructors communicate with students about course policy, schedule, and other logistical issues, as well as to help students stay on track. Examples include instructors using various strategies to keep students on track, such as posting a "due date checklist" regularly, sending regular announcements and reminders, or reaching out to individual students who are missing assignments or show signs of risk, such as a lack of activities or low grades. The fourth type of interaction is *student–student academic interaction (SSAI), which* happens between students and is related to the content of the course. An example of student–student academic interaction would be collaborative work, such as group assignments or peer review. The fifth type of interaction is *student–student social interaction (SSSI),* which also happens between students but is not directly related to the course content. Examples include asking students to add personal profiles to the learning management system (LMS) or inviting students to introduce themselves in an engaging way. The last type of interaction is *student–content academic interaction (SCAI)* and typically pivots on improving student meaningful engagement with course materials and thus their understanding of the course content. Some example strategies to promote student–content academic interaction include providing lectures through video in addition to PowerPoints, encouraging students to do self-testing, and encouraging students to reflect on their learning.

Interaction and Student Outcomes

Several studies have shed light on the positive correlation between various forms of interaction and online student outcomes. For instance, Wei et al. (2015) found that increased student interaction with both course content and management tools led to improved performance on exams, discussion boards, and group projects. Glazier (2016) found that students who

engaged in interpersonal rapport-building exercises with their instructors, such as personalized communication, earned higher grades and were less likely to drop out. Additionally, Lee and Recker (2021) conducted a comprehensive analysis of data from 72 online university math courses and concluded that instructor presence in discussion boards positively impacted student grades.

Similar benefits were also reported for peer interactions. For example, Kurucay and Inan (2017) found that students who interacted more with their peers achieved higher grades than those with limited peer interaction. Shelton et al. (2017) demonstrated that the frequency of interaction between peers strongly predicted student persistence in online courses. Using a quasi-experimental design, Bettinger et al. (2016) found that personalized communication between students, such as responding specifically to another student's discussion board posts and addressing them by name, enhances student grades.

Research has also provided insights into the potential mechanisms through which interaction is critical to students' academic performance. For example, student engagement is widely recognized as a key determinant of success in college (Bowden et al., 2019; Chen et al., 2010; Marti, 2008; Soffer & Cohen, 2019), and survey-based research indicates that student–student and instructor–student interactions are critical to promoting student engagement in online courses (Cole et al., 2021; Dixson, 2010; Kordrostami & Seitz, 2022; Miao et al., 2022; Van Wart et al., 2020; Wang et al., 2022). For instance, in a large-scale psychometric analysis, Van Wart et al. (2020) found that students valued several key interaction practices that promote teaching presence, online social comfort, interactive modality, and social presence. In a similar vein, Martin et al. (2018) found that students perceived instructors' timely responses and personal introductions as helpful practices to support their learning engagement.

A number of studies have conducted formal mediation analysis to explore how interaction indirectly influences key student outcomes, such as learning, grades, and satisfaction, through engagement as an important mediator. For instance, Gray and DiLoreto (2016) utilized structural equation modeling to assess how learner interaction and instructor presence impact students' perceived learning. They found that both types of interaction directly predicted student engagement, which, in turn, significantly improved perceived learning. Additionally, they found statistically significant indirect effects, which indicates that interaction types and instructor presence affected these outcomes by enhancing engagement. Kucuk and Richardson (2019) adopted a similar approach and explored the effects of various interactive practices, including teaching presence, social presence, and cognitive presence, on student satisfaction while explicitly examining engagement as a mediator. Their study provided additional support that interactive practices indirectly shape student satisfaction by enhancing engagement.

Limitations of the Existing Studies and the Unique Contribution of the Present Study

While an extensive body of research has highlighted the importance of interaction-oriented practices in online courses, there are still substantial research gaps that warrant further investigation. First, much of the current research has been small-scale studies conducted at four–year research university settings, and it is unclear to what extent these findings may speak to online courses at community colleges that serve a diverse student body with varying levels of digital literacy. Furthermore, existing research has predominantly focused on the overall relationship between interaction-oriented teaching practices and student outcomes, while there is

limited knowledge of how these practices might address learning gaps among historically marginalized groups. Additionally, previous studies seldom incorporate a comprehensive framework that includes the diverse types of interactions and distinguish them by their pedagogical goals. Consequently, while it is widely acknowledged that interaction contributes to the educational experience in online courses, there is limited understanding of the relative importance of specific practices. For instance, student–student interactions aimed at social engagement, such as discussion forums or peer group chats, may have different effects on student performance compared to those focused on academic collaboration, such as problem-solving tasks or group projects. Accordingly, a framework that incorporates and considers the nuanced distinctions between practices targeting different types of interactions will be able to provide more practical insights.

Our study aims to address several critical gaps in the existing literature on online education. First, our investigation focuses on community college online courses, a setting that has been relatively understudied despite its increasing importance in higher education. To achieve a comprehensive understanding of interaction-oriented teaching practices, we draw on the person–purpose framework by Orona et al. (2022) that integrates the diverse types of interaction that take place in online courses. Furthermore, different from previous studies that typically focus on a handful of online courses, we collected instructional practices through a large-scale survey that involves nearly 400 instructors linked with around 10,000 student course enrollment records from almost two dozen community colleges. To our knowledge, this unique dataset makes our study one of the most extensive investigations into the associations between interaction-oriented teaching practices and student outcomes in higher education research. Finally, our study goes beyond merely assessing the overall impact of these practices on student concurrent course outcomes, but also explores how these practices influence critical downstream outcomes, such as college persistence, as well as the role of these practices in mitigating equity gaps among historically marginalized groups.

Methods

Setting, Sample, and Data Sources

Our study was conducted at a state community college system (SCCS) in the southeastern United States that includes more than 20 institutions. Altogether, these institutions serve more than 200,000 students. In the fall term of 2019, all instructors who taught at least one online course at SCCS in the last three years were invited to respond to a survey that collects information on instructors' use of interaction-oriented teaching practices and their perceptions related to the use of these practices. The survey includes a total of 34 questions on instructional practices. It was developed based on predominant theoretical frameworks of effective online instruction (e.g., Anderson, 2004; Berge, 1995; Moore, 1989) and was further refined drawing on the authors' prior work (Orona et al., 2022).

Participants were asked at the beginning of the survey to specify the course they would be referencing when answering subsequent questions regarding their teaching practices. All the questions were framed to retrospectively elicit instructors' frequency of using each type of interaction-oriented practices in the specified online course. At the end of the term, SCCS

provided information on student demographic characteristics as well as their college transcript records, which were linked to the survey data.

Among the roughly 2,000 instructors contacted, a total of 369 instructors completed the survey and were successfully matched with the college administrative data, yielding an approximately 15% response rate. These instructors taught 88 different courses which enrolled 9,478 unique students. Table 1 provides the characteristics of these instructors (e.g., 71 percent were female, 91 percent identified as White, and 54 percent were employed full-time), their students (e.g., 67% were female and 31% identified as URM), and their courses (e.g., 20% were Math courses). Some students were enrolled in multiple courses taught by this sample of instructors, resulting in N = 10,107 enrollment records with an overall pass rate of 70%. In analyses focusing on letter grades, we excluded withdrawal, incomplete, and pass/fail grades, resulting in N = 8,959 enrollment records.

Table 1

Sample Summary Statistics

	N	M	SD
Panel A: Instructor characteristics			
Female instructor	369	0.71	0.46
White instructor	369	0.91	0.28
Instructor is full time	369	0.54	0.50
OL course built from scratch	369	0.31	0.46
OL course built from F2F	369	0.43	0.50
OL course built from other	369	0.02	0.15
Taught F2F version	369	0.82	0.38
PhD/Professional Degree	369	0.29	0.45
Masters	369	0.66	0.47
Years teaching in system	369	11.83	7.64
Overall years teaching	369	14.64	9.06
Taught 1 online course	369	0.13	0.33
Taught 2 to 5 online courses	369	0.51	0.50
Taught 6 to 10 online courses	369	0.13	0.33
Primarily teaches OL courses	369	0.27	0.44
Teaching is primary career	369	0.75	0.43
Panel B: Student characteristics			
Female	9450	0.67	0.47
Age during term	9478	25.42	8.21
Full-time	9478	0.44	0.49
First-Generation	9478	0.27	0.44

First-Term in college	9478	0.17	0.38
URM	9478	0.31	0.46
Grade in class	8411	2.72	1.42
Pass C or above	9468	0.70	0.45
Panel C: Course characteristics			
Natural Science	88	0.06	0.19
Humanities	88	0.08	0.25
Social Science	88	0.13	0.29
Math	88	0.20	0.39
English	88	0.11	0.29
Interdisciplinary Studies	88	0.04	0.19
Physical Education	88	0.02	0.11
Foreign language	88	0.01	0.04
Art	88	0.02	0.10
Occupation field 1	88	0.09	0.25
Occupation field 2	88	0.06	0.21
Occupation field 3	88	0.08	0.23
Occupation field 4	88	0.03	0.14
Occupation field 5	88	0.02	0.10
Occupation field 6	88	0.06	0.19

Notes. Examples of occupational fields include healthcare, information technology (IT), and manufacturing.

Data Collection and Analysis

Instructional Practices

The survey collected information on six categories of practices depending on the pedagogical purpose of the interactions: (i) instructor–student academic interaction (ISAI), (ii) instructor–student social interaction (ISSI), (iii) instructor–student course managerial interaction (ISCMI), (iv) student–student academic interaction (SSAI), (v) student–student social interaction (SSSI), and (vi) student–content academic interaction (SCAI). Table 2 provides specific survey items for each category of practice, the sample average for each item, and the average across items within each category ("subdomain scores"). To capture an overall interaction-oriented practice (IOP) score across all six categories, we standardized the six subdomain scores, summed them together, and standardized them again, resulting in an index with a mean of 0 and a standard deviation of 1.

Student Course Performance Outcomes

We focused on two course performance measures: (i) course completion was a dichotomous variable, measuring whether a student successfully completed a course with a grade that was C or higher, as opposed to either receiving a grade that was below C or withdrawing from the course; (ii) course grade was measured on a 0 to 4 grading scale among students who persisted through the end of the course and had a valid course grade.

Downstream Outcomes

Considering that learning experiences in a course may influence a student's overall engagement with a college and subsequent enrollment decisions, we also examined students' college persistence as a downstream outcome, measured as students' persistence into the following term in college, as opposed to dropping out of college or stopping out. College persistence is imperative when it comes to economic opportunity, especially among disadvantaged populations. Methodologically, downstream outcomes also help to address the concern that course outcome measures, such as course grades, may be subject to instructor leniency in grading criteria.

Model Specification

In view of the hierarchical structure of the data where students were nested within courses, we used multilevel regression analyses that included both student-level and class-level controls to examine the relationship between interaction-oriented teaching practices and student outcomes. Taking the overall interaction-oriented practice (IOP) score as an example, the model writes as follows:

$$Y_{ij} = \beta_{0j} + \beta_{1j} URM_{ij} + std_{ij} + \xi_{ij} \quad (1)$$

$$Where\ \beta_{0j} = \gamma_{01} IOP_j + tch_j + crs_j + sub_s + \mu_{0j}$$

$$\beta_{1j} = \gamma_{10} \quad (2)$$

$$Y_{ij} = \gamma_{00} + \gamma_{01} IOP_j + \gamma_{10} URM_{ij} + \gamma_{11} IOP_j * URM_{ij} + tch_j + crs_j + std_{ij} + \mu_{0j} + \xi_{ij} \quad (3)$$

The student-level regression (Equation 1) examines whether the course performance Y_{ij} of student i in course j is associated with URM status (URM_{ij}), while controlling for other student-level variables (std_{ij}), such as age and first-generation student status. The course-level regression (Equation 2) further models the intercept β_{0j} of Equation 1 (i.e., the average course performance) as a function of observable course-level characteristics, including the overall interaction-oriented practice score (IOP_j), teacher characteristics (tch_j), course characteristics (crs_j), and subject fixed effects (sub_s). The vector of course characteristics (crs_j) includes all course-level variables listed in Table 1. In addition, we further constructed a "course difficulty measure" that was calculated as the average student course grades in face-to-face sections of a given course taught by any instructor in the past three years to address the possibility that courses in the same subject area may still vary in the level of difficulty. Substituting Equation 2 into Equation 1 yields the multilevel model. We further included an interaction term between the IOP score and student URM status to allow the relationship between IOP and student outcomes to vary by URM status in Equation 3. Accordingly, the coefficient r_{01} captures the relationship between IOP score and performance outcomes for non–URM students, while r_{11} captures the interaction effect — the difference in this relationship between URM and non-URM students. Thus, the sum of r_{01} and r_{11} captures the relationship between the IOP score and performance outcomes for URM students.

Results

How Are Instructors Engaged in Interaction-Oriented Teaching Practices?

We first describe the extent to which instructors were engaged in various interaction-oriented teaching practices. Table 2 suggests instructors prioritize instructor–student interactions over student–student interaction. For example, both the ISAI and SSAI use the 5-point Likert scale of 1 = "Never" and 5 = "Every Week." An ISAI of 3.66 suggests that, on average, instructors in our sample engage in instructional practices involving instructor–student academic interactions approximately between once and every two weeks, while an SSAI of 1.80 implies that instructional practices focused on student–student academic interactions between never and only once during a semester.

Within a specific domain, there are substantial variations in instructors' engagement with specific practices. For example, in the domain of instructor–student academic interaction (ISAI), the most widely implemented practice is "Providing feedback (beyond a grade) on student work" (M = 4.57, or every week or two), while the least is "Interacting with students using synchronous media (e.g., Skype or other video conference tools)" (M = 2.06, or about once a semester).

Table 2

Summary Statistics of Interaction-Oriented Practices

Practice	Full Item	M	SD
Panel A: Instructor–Student Interaction-oriented Practices			
ISAI	**Instructor–Student Academic Interaction (5 = Every Week)**	3.66	0.77
ISAI_1	Providing face–to–face office hours for students to ask academic–related questions	3.47	1.82
ISAI_2	Providing feedback beyond a grade on student work	4.57	0.84
ISAI_3	Directly responding to student postings regarding academic content on discussion forums	4.27	1.23
ISAI_4	Interacting with students using synchronous media e.g., Skype or other video conference tools	2.06	1.45
ISAI_5	Interacting with students using asynchronous media discussion boards, etc.	4.27	1.21
ISSI	**Instructor–Student Social Interaction (1 = Yes)**	0.83	0.25
ISSI_1	I introduced myself to my students via audio, video, or images excluding emails only.	0.79	0.41
ISSI_2	I tried to make my personality come through in my communication with students.	0.97	0.17
ISSI_3	I shared aspects of my hobbies, interests, pets, and other aspects of my life with my students.	0.85	0.35
ISCMI	**Instructor–Student Course Managerial Interaction (5 = Very Frequently)**	3.59	0.40
ISCMI_1	Sending announcements or reminders to students about course content and assignments e.g., weekly check–ins	4.84	0.47

ISCMI_2	When I gave a course assignment, I provided explicit grading criteria e.g., rubric.	4.36	0.91
ISCMI_3	When I recognized struggling students, I offered additional support e.g., study tips, resources, and advice.	4.02	0.84
ISCMI_4	When a student asked a question about logistics and course requirements, I quickly responded within 24 hours.	4.70	0.50
ISCMI_5	Provide opportunities for students to give feedback about the course	2.85	1.22
ISCMI_6	provided explicit grading criteria e.g., rubric for discussion forum assignments.	0.88	0.33
Panel B: Student–Student Interaction-oriented Practices			
SSAI	**Student–Student Academic Interaction (5 = Every Week)**	1.80	0.90
SSAI_1	How often did you require students to rate the individual performance of team members on projects?	1.44	0.93
SSAI_2	How often did you provide collaborative work e.g., group assignments, reports	1.83	1.19
SSAI_3	How often did you assign students to interact with peers through student presentations asynchronously or synchronously?	2.22	1.51
SSSI	**Student–Student Social Interaction (1 = Yes)**	0.64	0.33
SSSI_1	I encouraged my online students to get to know each other more than what is required for assignments or tasks.	0.63	0.48
SSSI_2	I asked my students to introduce themselves using an icebreaker discussion.	0.88	0.33
SSSI_3	I provide a virtual lounge where students can meet informally to share common interests.	0.49	0.50
Panel C: Student–Content Interaction-oriented Practices			
SCAI	**Items 1–7 (5 = "Very Frequently") and 8–13 (5 = "Weekly")**	2.70	0.40
SCAI_1	Explicitly connected new lessons with prior content	4.13	0.78
SCAI_2	Summarized the big ideas in the course	4.25	0.81
SCAI_3	Emphasized important information/exam content	4.39	0.72
SCAI_4	Emphasized application of facts, theories, or methods to practical problems or new situations	4.16	0.80
SCAI_5	Emphasized analysis of an idea, experience, or line of reasoning in depth by examining its parts	3.95	0.95
SCAI_6	Emphasized evaluation of a point of view, decision, or information source	3.82	1.02
SCAI_7	Emphasized the formation of a new idea or understanding from various pieces of information	3.92	0.89
SCAI_8	Provided quizzes or problem sets	4.14	1.31
SCAI_9	I encouraged my students to do self–testing.	0.66	0.47
SCAI_10	encouraged my students to make outlines.	0.54	0.50
SCAI_11	I encouraged my students to make diagrams.	0.31	0.46
SCAI_12	encouraged my students to use flashcards.	0.38	0.49
SCAI_13	I encouraged my students to reflect on their learning.	0.78	0.41

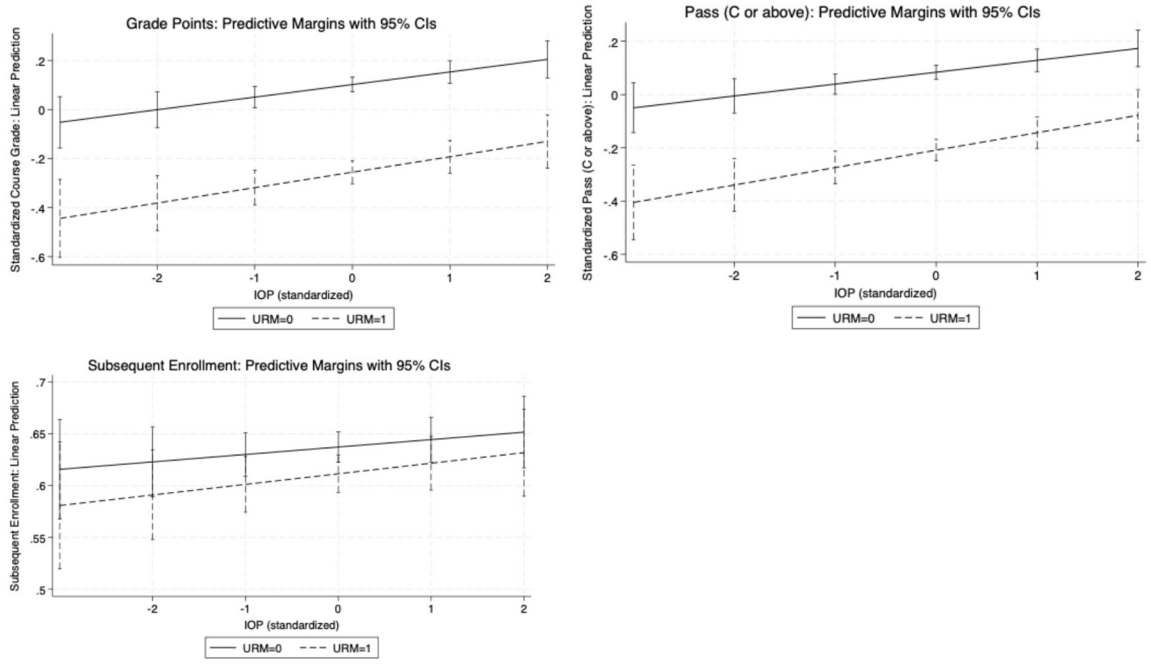
Note. ISAI, SSAI, and SCAI 8–13 items used a 5–point scale of 1 = "Never," 2= "Once," 3 = "Three times in total during the semester," 4 = "Every two weeks," and 5 = "Every Week." ISSI and SSSI items were binary, with 0 = "No" and 1 = "Yes." ISCMI and SCAI 1–7 items used a 5–point scale of 1 = "Never," 2= "Rarely," 3 = "Occasionally," 4 = "Frequently," and 5 = "Very Frequently."

Are Courses with Higher Overall IOP Scores Associated with Better Student Course Performance Outcomes and Smaller Racial Gaps?

To contextualize the role of interaction-oriented practices in shaping student outcomes, we first used our hierarchical regression models (Equation 3) to predict course grades, completion rates, and subsequent enrollment with different values of IOP indices. Figure 1 visualizes these relationships and indicates that higher IOP scores are generally associated with better student outcomes. In addition, although there is a consistent performance gap between URM and non-URM students, URM students seem to show a steeper increase in predicted course completion and subsequent enrollment as the level of IOP increases.

Figure 1

Predicted Student Outcomes by Different IOP (Interaction-oriented Practice) Scores and URM Status



To formally test whether these observed patterns reflect statistically significant effects, Table 3 presents estimates based on Equation 3. The results indicate that there were significant gaps between URM and non-URM students across all three outcome measures. Specifically, URM students, on average, had lower grade points by 0.36 standard deviations ($p < .001$), had a reduced probability of passing the course with a grade of C or higher by 13 percentage points ($p < .001$), and were 3 percentage points less likely to stay enrolled in college subsequently ($p < .05$). Students taking a course with high practice instructors showed improved course outcomes.

For each unit increase in the IOP index, students, on average, experienced a 0.05 standard deviation boost in course grades ($p < .05$) and were more likely to pass a course with C or above by 2 percentage points ($b = .02, p < .05$). Yet, the interaction terms are consistently non-significant, indicating that URM and non-URM benefit similarly from higher levels of interaction practices.

Table 3

Estimated Effects of IOP (Interaction-Oriented Practice) on Student Outcomes by URM Status

	Grade Points	Pass (C or above)	Subsequent Enrollment
URM	-0.36 (0.02)***	-0.13 (0.01)***	-0.03 (0.01)*
IOP Index	0.05 (0.02)*	0.02 (0.01)*	0.01 (0.01)
URM*IOP Index	0.01 (0.02)	0.01(0.01)	0.00 (0.01)
N	8,854	9,993	10,054

Note. Grade points are z–score standardized. Pass (C or above) is coded 0/1. IOP = Interaction-oriented Practice. URM = Underrepresented minority. Standard errors in parentheses. + p<0.1 * p<0.05 ** p<0.01 *** p<0.001

Are Specific Subdomains of IOP Related to Course Outcomes and Racial Gaps More Strongly?

Table 4 further displays the associations between each subdomain of IOP and student outcomes. The table also presents interaction terms between each subdomain and URM status to assess whether the effects of a given subdomain vary by student URM status. Student–student social interaction (SSSI, $b = .02$, $p < .05$) and student–student academic interaction (SSAI, $b = .02, p < .05$) show modest but significant benefits for students' probability of passing a course with a C or higher. In addition, ISCMI shows a positive relationship with subsequent term enrollment ($b = .02, p < .05$), indicating that when instructors were engaged more actively in instructor–student course managerial interactions, students, on average, were more likely to persist into the following term.

The interaction terms between URM status and IOP subdomains generally remain non–significant. This suggests that students benefited from higher engagement in interaction-oriented practices in a similar way regardless of their URM status. However, one notable exception is the interaction between ISCMI (instructor–student course managerial interaction) and URM status, which is positively and significantly related to both course grades ($b = .07, p < .05$) and course completion ($b = .03, p < .05$). This suggests that, compared to non-URM students, URM students benefited significantly more from instructor–student course managerial interactions. Accordingly, when instructors were engaged with higher levels of ISCMI, such as sending regular check-ins to keep students on track or proactively identifying students who were struggling and reaching out to them, the performance gaps between URM and non-URM students became narrower.

Table 4

Estimated Effects of Subdomains of IOP (Interaction-Oriented Practice) on Student Outcomes by URM Status

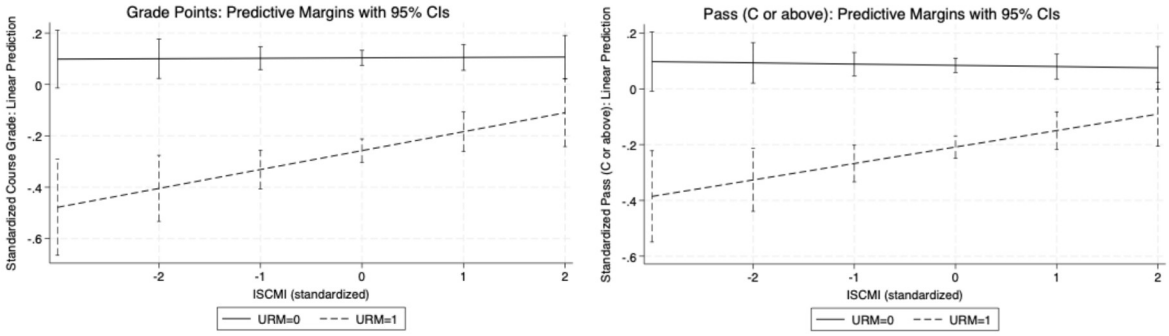
	Grade Points	Pass (C or above)	Subsequent Enrollment
URM	-0.35 (0.02)***	-0.13 (0.01)***	-0.02 (0.01)*
ISAI	0.01 (0.02)	-0.01 (0.01)	-0.00 (0.01)
ISCMI	0.00 (0.02)	-0.00 (0.01)	0.02 (0.01)*
ISSI	0.02 (0.02)	0.00 (0.01)	-0.00 (0.01)
SSAI	0.01 (0.02)	0.02 (0.01)*	0.02 (0.01)
SSSI	0.04 (0.02)	0.02 (0.01)*	-0.00 (0.01)
SCAI	0.01 (0.02)	0.00 (0.01)	-0.02 (0.01)+
URM*ISAI	-0.04 (0.03)	-0.01 (0.01)	0.01 (0.01)
URM*ISCMI	0.07 (0.03)*	0.03 (0.01)*	-0.00 (0.01)
URM*ISSI	-0.03 (0.03)	-0.01 (0.01)	-0.03 (0.01)*
URM*SSAI	0.03 (0.02)	0.01 (0.01)	0.00 (0.01)
URM*SSSI	–0.00 (0.03)	–0.00 (0.01)	0.00 (0.01)
URM*SCAI	–0.02 (0.03)	–0.00 (0.01)	0.02 (0.01)
N	8,854	9,993	10,054

Note. Grade points are z–score standardized. Pass (C or above) is coded 0/1. ISAI = instructor–student academic interaction; ISSI = instructor–student social interaction; ISCMI = instructor–student course managerial interaction. SSAI = student–student academic interaction; SSSI = student–student social interaction. SCAI = student–content academic interaction. URM = Underrepresented minority. Standard errors in parentheses. + p<0.1 * p<0.05 ** p<0.010 *** p<0.001

To further contextualize the interactional effects of instructor–student course managerial interactions on course outcomes, we used our model to predict course grades and completion rates across different values of ISCMI for URM and non–URM students, respectively. Results presented in Figure 2 visually demonstrate how increased use of ISCMI reduced the racial gaps in course performance. Specifically, as instructors engaged more in ISCMI practices, non–URM students' course performance remained relatively stable. In contrast, URM students experienced strong improvement in both course grades and completion rates. As a result, the racial gaps in course outcomes progressively narrowed. At high levels of ISCMI (two standard deviations above the mean), the model predicts that the racial performance gap is nearly closed.

Figure 2

Predicted Student Outcomes by Different ISCMI (Instructor–Student Course Managerial Interactions) Scores and URM Status



In view of the potential of Instructor–Student Course Managerial Interaction (ISCMI) practices in reducing racial equity gaps, we further disentangle which specific ISCMI practices drive these effects. To achieve this goal, we replaced the ISCMI index score with a vector of six individual ISCMI practices listed in Table 2. We then included these six variables and their interactions with URM status in the model. Importantly, the model retains all prior control variables, other subdomains of IOP, and their interactions with URM. Accordingly, the new model teases out the effects of each of the ISCMI practices from potential influences of other interaction-oriented practices.

The results presented in Table 5 show that not all ISCMI practices contributed equally to reducing equity gaps between URM and non–URM students. Notably, ISCMI_3 (active outreach to struggling students) shows significant positive interaction with URM status for both grade points ($b = .12$, $p < .001$) and course completion ($b = .04$, $p < .01$). These results suggest that URM students disproportionately benefited from proactive outreach to struggling students. In addition, ISCMI_4 (responding to student questions about logistics and course requirements quickly) also shows marginally significant interaction with URM on course completion ($b = .04$, $p < .1$). This suggests that URM students benefited particularly strongly from timely and responsive communication regarding course logistics and expectations.

Table 5

Estimated Effects of Specific ISCMI Practices by URM Status

	Grade Points	Pass (C or above)	Subsequent Enrollment
ISCMI_1	0.03 (0.05)	–0.01 (0.02)	–0.00 (0.02)
ISCMI_2	–0.01 (0.02)	–0.00 (0.01)	0.01 (0.01)
ISCMI_3	–0.02 (0.03)	–0.01 (0.01)	0.00 (0.01)
ISCMI_4	–0.01 (0.04)	0.00 (0.02)	–0.00 (0.02)
ISCMI_5	0.02 (0.02)	0.00 (0.01)	0.01 (0.01)
ISCMI_6	–0.01 (0.06)	0.02 (0.03)	0.06 (0.03)*
URM=1 # ISCMI_1	–0.02 (0.06)	–0.01 (0.02)	0.02 (0.03)

URM=1 # ISCMI_2	–0.00 (0.03)	0.01 (0.01)	–0.01 (0.01)
URM=1 # ISCMI_3	0.12 (0.03)***	0.04 (0.01)**	0.01 (0.01)
URM=1 # ISCMI_4	0.06 (0.05)	0.04 (0.02)+	0.02 (0.02)
URM=1 # ISCMI_5	0.00 (0.02)	0.01 (0.01)	–0.01 (0.01)
URM=1 # ISCMI_6	0.10 (0.08)	–0.03 (0.03)	–0.01 (0.04)
N	8,854	9,993	10,054

Note. Grade points are z–score standardized. Pass (C or above) is coded 0/1. For ISCMI items, see Table 2. URM = Underrepresented minority. Standard errors in parentheses. + p<0.1 * p<0.05 ** p<0.010 *** p<0.001

Discussion and Conclusion

Summary of Key Findings and Implications

Distance learning through online coursework is playing an increasingly important role in higher education, especially at open-access institutions that enroll a large proportion of adult learners who benefit from the flexibility of distance learning. Yet, students' low performance in these courses has been a persistent concern, and colleges have been actively seeking evidence-based practices that can help colleges and instructors design and implement high-quality online courses that could fundamentally improve student learning outcomes. Drawing on a unique dataset that links instructors' use of practices aimed at promoting interaction, our study provides empirical evidence on the benefits of various interaction-oriented practices on student online learning outcomes.

Overall, our results support the theoretical conjecture that interaction-oriented practices play an important role in facilitating learning and engagement in college online courses. Even after accounting for a rich set of student and instructor characteristics, course subject areas, overall course difficulty, and average student grades in face-to-face sessions, we find positive relationships between higher levels of engagement in interaction-oriented practices and student performance outcomes. These findings underscore the value of fostering interactivity in online education. The positive impacts on course completion rates are particularly noteworthy for community colleges, where failure to complete a course, especially introductory courses, can substantially increase the probability of early college withdrawal and decrease the probability of earning a postsecondary credential (Calcagno et al., 2007). Unsuccessful learning experiences can be particularly consequential for URM students: A Black student who withdraws or fails his/her introductory course has a 67% chance of not earning any postsecondary credential, compared with a 48% chance for a White student (Chen & Soldner, 2013).

Our results also indicate that the benefits of interaction-oriented practices are not uniform across all domains of interaction. Among the six domains examined, practices that promote peer social interaction are the strongest predictor of higher course performance for all students. This finding aligns with prior research showing that students in online courses frequently report feelings of isolation and a lack of "social presence"—the perception of being connected to others in a computer–mediated environment (e.g., Richardson et al., 2017; Shearer, 2013). While the current literature has consistently highlighted the importance of enhancing meaningful peer

interactions, most of these studies focus on collaborative learning opportunities that facilitate academic interactions between students. While we also identify a positive coefficient for SSAI (student–student academic interaction) on course performance, the size of the effect is only about half of the effect of SSSI (student–student social interaction). While we are not able to draw any definitive conclusion regarding the comparison between SSAI and SSSI based on the sample of the current study, our results suggest that fostering opportunities for purely social connections, such as encouraging students to add personal profiles to the learning management system (LMS) or participate in engaging introductions, can have a substantial impact on student outcomes. This highlights the importance of designing online courses to address the social dimensions of learning.

Contrary to our expectations, instructor–student interactions (ISSI & ISAI) were not significantly associated with student online performance outcomes. The specific reason why instructor–student interactions did not matter in this specific context is beyond the scope of the present study. It is possible that the effect of the student–faculty interactions may largely depend on qualitative features of the interaction, such as the content of the interaction or tone used by the faculty, which cannot be captured by our survey items. Future research that has access to richer data on course interaction dialogues may wish to explore these possibilities.

Finally, among the six domains examined, practices targeting instructor–student course management interaction (ISCMI) emerged as a promising way to reduce equity gaps by disproportionately improving the course performance of racial minority students. This finding aligns with prior research suggesting that learners may not be equally predisposed to succeed in online learning due to different levels of self-directed learning skills (e.g., Hart et al., 2018). Indeed, existing literature on learning autonomy suggests that White students and individuals with high prior educational attainment, on average, exhibit higher levels of self–directed learning skills than URM students and individuals with lower educational attainment (e.g., Hoskins & Van Hooff, 2005; Muse, 2003; Stewart et al., 2010; Wiggam, 2004). Consequently, practices that provide structure, monitor progress, and help students stay on track are especially beneficial for URM students. Indeed, our subsequent analyses that examine the specific managerial practices indicate that URM students disproportionately benefited from proactive outreach to struggling students and timely guidance about course expectations. Considering that course management-related communications are often addressing the whole class rather than messages tailored to personal needs, it should be relatively easy for instructors to incorporate these practices into their online instruction. Institutions seeking to improve online teaching and learning outcomes may also consider incorporating these practices into the professional training curriculum for online instructors.

Limitations and Future Research

There are several limitations to this study. First, our reliance on self-reported survey data introduces potential validity issues (Maul, 2017). For instance, instructors could respond to interaction-oriented practice questions in socially desirable ways. Although we believe this risk is minimal, given that the survey was designed for research rather than evaluation, future research could validate our findings through more objective measures of teaching practices. In addition, it is important to note that the benefits of specific types of interaction may vary depending on the local contexts and student population. Accordingly, institutions and researchers

may wish to tailor the survey to the local context and examine the relationship between interaction-oriented practices and student outcomes using local data.

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Conflict of Interest

The authors declare no conflicts of interest with respect to the authorship or publication of this manuscript.

References

Adnan, M., & Anwar, K. (2020). Online learning amid the COVID–19 pandemic: Students' perspectives. *Journal of Pedagogical Sociology and Psychology*, 2(1), 45–51. https://doi.org/10.33902/JPSP.2020261309

Alqurashi, E. (2019). Predicting student satisfaction and perceived learning within online learning environments. *Distance Education*, *40*(1), 133–148. https://doi.org/10.1080/01587919.2018.1553562

Anderson, T. (2004). Towards a theory of online learning. Theory and practice of online learning, 2, 109-119. Athabasca University Press. https://doi.org/10.15215/aupress/9781897425084.01.04

Bambara, C. S., Harbour, C. P., Davies, T. G., & Athey, S. (2009). Delicate engagement: The lived experience of community college students enrolled in high-risk online courses. *Community College Review*, *36*(3), 219–238. https://doi.org/10.1177/0091552108327187

Berge, Z. L. (1995). The role of the online instructor/facilitator. *Educational Technology*, *35*(1), 22–30. https://trainingthetrainers2010.pbworks.com/f/The+Role+of+the+Online+Instructor.pdf

Bettinger, E., Liu, J., & Loeb, S. (2016). Connections matter: How interactive peers affect students in online college courses. *Journal of Policy Analysis and Management*, *35*(4), 932–954. https://doi.org/10.1002/pam.21912

Bettinger, E. P., Fox, L., Loeb, S., & Taylor, E. S. (2017). Virtual classrooms: How online college courses affect student success. *American Economic Review*, *107*(9), 2855–2875. https://doi.org/10.1257/aer.20151193

Bolliger, D. U., & Martin, F. (2018). Instructor and student perceptions of online student engagement strategies. *Distance Education*, *39*(4), 568–583. https://doi.org/10.1080/01587919.2018.1520041

Bork, R. H., & Rucks-Ahidiana, Z. (2013). Role ambiguity in online courses: An analysis of student and instructor expectations (Community College Research Center Working Paper No. 64). Teachers College, Columbia University.

Bowden, J. L. H., Tickle, L., & Naumann, K. (2019). The four pillars of tertiary student engagement and success: A holistic measurement approach. *Studies in Higher Education*, *46*(6), 1207–1224. https://doi.org/10.1080/03075079.2019.1672647

Calcagno, J. C., Crosta, P., Bailey, T., & Jenkins, D. (2007). Steppingstones to a degree: The impact of enrollment pathways and milestones on community college student outcomes. *Research in Higher Education*, *48*(7), 775–801. https://doi.org/10.1007/s11162-007-9053-8

Chen, P. S. D., Lambert, A. D., & Guidry, K. R. (2010). Engaging online learners: The impact of Web-based learning technology on college student engagement. *Computers & Education*, *54*(4), 1222–1232. https://doi.org/10.1016/j.compedu.2009.11.008

Chen, X., & Soldner, M. (2013). STEM attrition: College students' paths into and out of STEM fields (NCES 2014–001). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, US Department of Education. https://files.eric.ed.gov/fulltext/ED544470.pdf

Cole, A. W., Lennon, L., & Weber, N. L. (2021). Student perceptions of online active learning practices and online learning climate predict online course engagement. *Interactive Learning Environments*, *29*(5), 866–880. https://doi.org/10.1080/10494820.2019.1619593

Dixson, M. D. (2015). Creating effective student engagement in online courses: What do students find engaging? *Journal of the Scholarship of Teaching and Learning, 10*(2), 1–13. https://scholarworks.iu.edu/journals/index.php/josotl/article/view/1744

Garrison, D. R., Anderson, T., & Archer, W. (2003). A theory of critical inquiry in online distance education. *Handbook of Distance Education*, *1*(4), 113–127.

Garrison, D. R., & Cleveland-Innes, M. (2005). Facilitating cognitive presence in online learning: Interaction is not enough. *American Journal of Distance Education, 19*, 133–148.

Gherghel, C., Yasuda, S., & Kita, Y. (2023). Interaction during online classes fosters engagement with learning and self–directed study both in the first and second years of the COVID–19 pandemic. *Computers & Education*, *200*, 104795. https://doi: 10.1016/j.compedu.2023.104795

Glazier, R. A. (2016). Building rapport to improve retention and success in online classes. *Journal of Political Science Education, 12*(4), 437–456. https://doi.org/10.1080/15512169.2016.1155994

Gray, J. A., & DiLoreto, M. (2016). The effects of student engagement, student satisfaction, and perceived learning in online learning environments. *International Journal of Educational Leadership Preparation*, *11*(1), n1.

Hart, C. M., Friedmann, E., & Hill, M. (2018). Online course–taking and student outcomes in California community colleges. *Education Finance and Policy*, *13*(1), 42–71. https://doi.org/10.1162/edfp_a_00218

Hoskins, S. L., & Van Hooff, J. C. (2005). Motivation and ability: Which students use online learning and what influence does it have on their achievement? *British Journal of Educational Technology*, *36*(2), 177–192. https://doi.org/10.1111/j.1467-8535.2005.00451.x

Huntington-Klein, N., Cowan, J., & Goldhaber, D. (2017). Selection into online community college courses and their effects on persistence. *Research in Higher Education*, *58*(3), 244–269. https://doi.org/10.1007/s11162-016-9425-z

Jaggars, S. S., & Xu, D. (2016). How do online course design features influence student performance? *Computers & Education*, *95*, 270–284. https://doi.org/10.1016/j.compedu.2016.01.014

Jenkins, D., & Fink, J. (2015). What we know about transfer. Community College Research Center, Teachers College, Columbia University.https://ccrc.tc.columbia.edu/media/k2/attachments/what-we-know-about-transfer.pdf

Johnson, H. P., & Mejia, M. C. (2014). *Online learning and student outcomes in California's community colleges*. Public Policy Institute of California. https://www.ppic.org/wp-content/uploads/content/pubs/report/R_514HJR.pdf

Johnson, H. P., & Mejia, M. C. (2014**).** *Online learning and student outcomes in California's community colleges*. Public Policy Institute of California. https://www.ppic.org/wp-content/uploads/content/pubs/report/R_514HJR.pdf

Jung, I., Choi, S., Lim, C., & Leem, J. (2002). Effects of different types of interaction on learning achievement, satisfaction, and participation in web-based instruction. *Innovations in Education and Teaching International*, *39*(2), 153–162. https://doi.org/10.1080/14703290252934603

Kordrostami, M., & Seitz, V. (2022). Faculty online competence and student affective engagement in online learning. *Marketing Education Review*, *32*(3), 240–254. https://doi.org/10.1080/10528008.2021.1965891

Krieg, J. M., & Henson, S. E. (2016). The educational impact of online learning: How do university students perform in subsequent courses? *Education Finance and Policy*, *11*(4), 426–448. https://doi.org/10.1162/EDFP_a_00196

Kucuk, S., & Richardson, J. (2019). A structural equation model of predictors of online learners' engagement and satisfaction. *Online Learning*, *23*(2). https://doi:10.24059/olj.v23i2.1455

Kurucay, M., & Inan, F. A. (2017). Examining the effects of learner–learner interactions on satisfaction and learning in an online undergraduate course. *Computers & Education*, *115*, 20–37. https://doi.org/10.1016/j.compedu.2017.06.010

Ladson–Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, 32(3), 465–491. https://doi.org/10.3102/00028312032003465

Lee, J.–E., & Recker, M. (2021). The effects of instructors' use of online discussions strategies on student participation and performance in university online introductory mathematics

courses. *Computers & Education*, 162, 104084. https://doi.org/10.1016/j.compedu.2020.104084

Marti, C. N. (2008). Dimensions of student engagement in American community colleges: Using the community college student report in research and practice. *Community College Journal of Research and Practice*, *33*(1), 1–24. https://doi.org/10.1080/10668920701366867

Martin, F., & Bolliger, D. U. (2018). Engagement matters: Student perceptions on the importance of engagement strategies in the online learning environment. *Online Learning*, *22*(1), 205–222.

Martin, F., Ritzhaupt, A., Kumar, S., & Budhrani, K. (2019). Award–winning faculty online teaching practices: Course design, assessment and evaluation, and facilitation. *The Internet and Higher Education*, *42*, 34–43. https://doi.org/10.1016/j.iheduc.2019.04.001

Maul, A. (2017). Rethinking traditional methods of survey validation. *Measurement: Interdisciplinary Research and Perspectives*, *15*(2), 51–69. https://doi.org/10.1080/15366367.2017.1348108

Miao, J., Chang, J., & Ma, L. (2022). Teacher–student interaction, student–student interaction and social presence: Their impacts on learning engagement in online learning environments. *The Journal of Genetic Psychology*, 183(6), 514–526. https://doi.org/10.1080/00221325.2022.2094211

Moore, M. G. (1989). Three types of interaction. *American Journal of Distance Education*, *3*(2), 1–7. https://doi.org/10.1080/08923648909526659

Moore, M. G., Dickson–Deane, C., & Galyen, K. (2011). E-Learning, online learning, and distance learning environments: Are they the same? *The Internet and Higher Education*, 14(2), 129–135. https://doi:10.1016/j.iheduc.2010.10.001

Muse Jr, H. E. (2003). The web–based community college student: An examination of factors that lead to success and risk. *The Internet and Higher Education*, *6*(3), 241–261. https://doi.org/10.1016/S1096-7516(03)00044-7

Orona, G. A., Li, Q., McPartlan, P., Bartek, C., & Xu, D. (2022). What predicts the use of interaction-oriented pedagogies? The role of self-efficacy, motivation, and employment stability. *Computers & Education*, *184*, 104498. https://doi.org/10.1016/j.compedu.2022.104498

Quality Matters. (2014). Quality matters higher education rubric (5th ed.). *Annapolis, MD: Quality Matters*.

Quality Matters. (2018). Quality matters higher education rubric (6th ed.). *Annapolis, MD: Quality Matters*.

Ramos, D. & Sifuentez, B. (2021). Historically underrepresented students redefining college success in higher education. *Journal of Postsecondary Student Success, 1(2)*, 91–110. https://doi.org/10.33009/fsop_jpss127615

Richardson, J. C., Maeda, Y., Lv, J., & Caskurlu, S. (2017). Social presence in relation to students' satisfaction and learning in the online environment: A meta–analysis. *Computers in Human Behavior*, 71, 402–417. https://doi.org/10.1016/j.chb.2017.02.001

Shea, P., & Bidjerano, T. (2018). Online course enrollment in community college and degree completion: The tipping point. *International Review of Research in Open and Distributed Learning*, *19*(2). https://doi.org/10.19173/irrodl.v19i2.3460

Shearer, R. L. (2013). Theory to practice in instructional design. In M. G. Moore (Ed.), *Handbook of distance education* (pp. 251–267). Routledge.

Shelton, B. E., Hung, J.–L., & Lowenthal, P. R. (2017). Predicting student success by modeling student interaction in asynchronous online courses. *Distance Education*, 38(1), 59–69. https://doi.org/10.1080/01587919.2017.1299562

Soffer, T., & Cohen, A. (2019). Students' engagement characteristics predict success and completion of online courses. *Journal of Computer Assisted Learning*, *35*(3), 378–389. https://doi.org/10.1111/jcal.12340

Stewart, C., Bachman, C., & Johnson, R. (2010). Students' characteristics and motivation orientations for online and traditional degree programs. *Journal of Online Learning and Teaching*, *6*(2), 367–379. https://web.archive.org/web/20180422154324id_/http://jolt.merlot.org/vol6no2/stewart_0610.pdf

Streich, F. E. (2014). Online education in community colleges: Access, school success, and labor-market outcomes (Doctoral dissertation, University of Michigan). University of Michigan Deep Blue Repository. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/108944/fstreich_1.pdf?sequence=1&isAllowed=yhttps://deepblue.lib.umich.edu/bitstream/handle/2027.42/108944/fstreich_1.pdf?sequence=1&isAllowed=y

Swan, K. (2002). Building learning communities in online courses: The importance of interaction. *Education, Communication & Information*, *2*(1), 23–49. https://doi.org/10.1080/1463631022000005016

Tinto, V. (1993). Leaving college: Rethinking the causes and cures of student attrition. *University of Chicago Press*. https://www.google.com/books/edition/Leaving_College/TlVhEAAAQBAJ?hl=en&gbpv=1&dq=Leaving+college:+Rethinking+the+causes+and+cures+of+student+attrition&pg=PR7&printsec=frontcover

Van Wart, M., Ni, A., Medina, P., Canelon, J., Kordrostami, M., Zhang, J., & Liu, Y. (2020). Integrating students' perspectives about online learning: A hierarchy of factors.

International Journal of Educational Technology in Higher Education, 17(1), 1–22. https://doi.org/10.1186/s41239-020-00229-8

Wagner, E. D. (1998, August). Interaction strategies for online training designs. Paper presented at the 14th Annual Conference on Distance Teaching & Learning, Madison, WI. ERIC Document ED 422 881. https://files.eric.ed.gov/fulltext/ED422881.pdfhttps://files.eric.ed.gov/fulltext/ED422881.pdf

Wang, Y., Cao, Y., Gong, S., Wang, Z., Li, N., & Ai, L. (2022). Interaction and learning engagement in online learning: The mediating roles of online learning self-efficacy and academic emotions. *Learning and Individual Differences*, *94*, 102128. https://doi.org/10.1016/j.lindif.2022.102128

Wanstreet, C. E. (2006). Interaction in online learning environments: A review of the literature. *Quarterly Review of Distance Education, 7*(4), 399–411.

Wei, H.-C., Peng, H., & Chou, C. (2015). Can more interactivity improve learning achievement in an online course? Effects of college students' perception and actual use of a course–management system on their learning achievement. *Computers & Education*, 83, 10–21. https://doi.org/10.1016/j.compedu.2014.12.013

Wiggam, M. K. (2004). *Predicting adult learner academic persistence: Strength of relationship between age, gender, ethnicity, financial aid, transfer credits, and delivery methods*. The Ohio State University.

Xu, D., & Jaggars, S. S. (2014). Performance gaps between online and face–to–face courses: Differences across types of students and academic subject areas. *The Journal of Higher Education*, *85*(5), 633–659. https://doi.org/10.1080/00221546.2014.11777343

Xu, D., & Xu, Y. (2020). The ambivalence about distance learning in higher education: Challenges, opportunities, and policy implications. In L. W. Perna (Ed.), *Higher education: Handbook of theory and research* (Vol. 35, pp. 351–401). Springer International Publishing.