Understanding Students' Self-regulation in a HyFlex Design Thinking Course

Dr. Lakshmy Mohandas, Purdue University at West Lafayette (COE)

Lakshmy Mohandas received her Ph.D. (2022) in Engineering Technology from Purdue University, Indiana. Her research interests include the HyFlex learning model, student engagement, equitable learning using different modes of participation, student motivation, and achievement goals.

Prof. Nathan Mentzer, Campbell University

Nathan Mentzer is an assistant professor in the College of Technology with a joint appointment in the College of Education at Purdue University. Hired as a part of the strategic P12 STEM initiative, he prepares Engineering/Technology candidates for teache

Ms. Adrie Koehler

Doctoral Student, Learning Design & Technology

Mr. Shawn Farrington, Purdue University at West Lafayette (COE)

Shawn Farrington is a Senior Lecturer in the Polytechnic Institute at Purdue University. He co-coordinates a first-year Design Thinking program and teaches several of his own sections. Shawn is also an Educational Psychology Ph.D. candidate at Purdue. His

Elnara Mammadova

Elnara is a Graduate Research Assistant in the Technology, Leadership and Innovation program at Purdue University. She is dedicated to her research on fostering inclusivity in the curriculum and ensuring digital accessibility of lesson materials for students in STEM classes in higher education.

Students' Self-regulation in a HyFlex Design Thinking Course

This is a complete research paper. HyFlex learning models have gained popularity as a result of the pandemic. Studies and surveys show the potential for blended learning models, like HyFlex, to improve higher education post-pandemic and for years to come. Simultaneously, researchers have consistently found that self-regulation impacts students' academic achievement in traditional classroom settings. Since online learning environments increases student autonomy, arguably, self-regulation learning skills are even more crucial to the success of learning in online settings than they are in traditional face-to-face classrooms. Although self-regulation is an important factor related to students' academic success, little is known about the role of self-regulation in blended learning environments in higher education. The research context for the study is a first-year design thinking course that is offered in a HyFlex format. In the course, students are given the flexibility to join the class synchronously remotely or face-to-face for every class meeting. Through this study, we attempt to understand the relationship between students' self-regulation and their choice of class participation on any given day. Self-regulation was measured using the MSLQ (Motivated Strategies for Learning Questionnaire).

Introduction

Although disruptions to education are common (e.g., severe weather, illness), the onset of COVID-19 severely interrupted teaching and learning at a scale that most educators and students had never previously experienced. Educators rapidly shifted their classrooms to online and hybrid formats to meet changing guidelines aimed at protecting public health and accommodating diverse learner needs (e.g., educating through quarantine, protecting high-risk students). As educators continue to navigate a lessening pandemic, a new educational normal has emerged, resulting in fundamental changes to classrooms, including, perhaps, the way educators and learners perceive and manage environmental constraints. While HyFlex (hybrid learning environments offering students flexible options to students to attend face-to-face or remotely) is an established approach for accommodating disruptions to learning and supporting learners' abilities to attend class under varying circumstances, the COVID pandemic has renewed interest and increased demand for implementing and effectively facilitating HyFlex methods [4]. As HyFlex environments offer flexibility to accommodate diverse needs, to be effective, these environments simultaneously require students to share more ownership in their learning process. To effectively manage the increased ownership afforded by HyFlex, learners arguably need effective self-regulation skills, especially as they navigate across and within different modalities, sometimes simultaneously. Therefore, to be able to design and facilitate effective HyFlex environments, educators must understand the relationship between students' self-regulation and their choice of daily participation across modality. In this research, by comparing students' self-regulation skills and attendance patterns, we examined the relationship between participation choices and self-regulation in a HyFlex environment.

Literature Review

HyFlex

HyFlex, short for hybrid-flexible, is an instructional format that simultaneously combines both online and face-to-face learning environments [1]–[3], offering students flexibility in how they choose to participate in a learning experience from class-to-class [4]. For instance, a course may be designed to livestream course activities, therefore allowing both face-to-face and remote students to listen to presentations and interact with peers synchronously, regardless of the modality they select [5].

In response to the COVID-19 Pandemic, HyFlex has been widely adopted due to the benefits it offers to both educators and students [6]–[8]. As the COVID-19 Pandemic declines, some scholars view HyFlex as a "new normal" for delivering learning experiences [7], [9]. According to Brian Beatty [1], benefits of HyFlex include offering students flexible and multimodal access, increased control over their schedule, and wider learning resources. At the same time, instructors can benefit from using HyFlex with students in small or large groups, as it offers a way to create consistent learning materials and experiences for students in different circumstances, efficiently manage a multimodal learning environment, and reach and support more learners by using the flexibility of switching between in-person and online instruction [1]. Overall, HyFlex learning experiences offer flexible and accessible options to educators and students, potentially creating a "new normal" for classrooms to provide increased autonomy for stakeholders.

While HyFlex offers many advantages, it also presents several challenges. For instance, in HyFlex environments, learners must manage their learning and time, troubleshoot technological issues as they arise, and in problem-centered environments, collaborate with peers independently, with an instructor providing minimal guidance [5], [10], [11]. Students who are struggling with self-regulation may choose to participate remotely instead of face-to-face (e.g., just hit the join button on the calendar), yet they struggle to make meaningful contributions within their multi-modal group [7] because of the complexities. In short, in HyFlex environments, learners share more ownership in the learning experience as they must make decisions about how they will participate based on their personal lives [12] and other factors (e.g., daily schedule, weather, other classes, extracurricular activities, desire to sleep longer)[13]. At the center of these challenges are issues related to self-regulation. In a HyFlex experience, students determine the amount of effort they will invest when faced with obstacles and managing interruptions, and to get the most out of the experience, strong self-regulation skills are essential.

Self-Regulation

Self-regulation refers to a process by which learners consciously and proactively set goals and establish strategies for achieving those goals by metacognitively activating their relevant cognitions and motivations [14], [15]. Derived from social-cognitive theory, Zimmerman [14] established a cyclical framework of self-regulation that is divided into three phases: 1) forethought phase (processes promoting a learning mindset by involving one's beliefs, attitudes, and processes before any academic task), 2) performance control phase (intentionally

participating in learning activities specific to a personal strategic plan and augmenting learning by utilizing self-control and self-observation processes), and 3) self-reflection phase (evaluating personal performance against goals, learning outcomes, or self-standards and modifying future learning strategies). The cyclical nature of this model posits that completion of one phase informs and influences the next phase(s), and reverting back to a previous phase is possible [16]. Viewing self-regulation in this fashion exposes a process of planning and adapting performance based on self-generated behaviors and cognitions in an effort to reach self-set goals [14]. Cleary and Zimmerman [16] posited that self-regulated learners are generally those that proactively incorporate self-regulation processes (e.g., goal setting, self-evaluation), along with task strategies (e.g., time management, studying), and self-motivational expectations (e.g., intrinsic interest).

In problem-centered learning environments, self-regulation is especially important as learners with limited self-regulative skills have difficulties with anticipating potential solutions, focusing on important aspects of the problem, and self-monitoring progress [17]. HyFlex problem-centered learning environments then are particularly complex, as blended learning environments can attribute to increased self-regulation due to the level of learner control required and personalized learning present [18]. In online learning environments, evidence suggests that utilizing self-regulation strategies is vital in academic success as structures that exist in face-to-face classrooms do not exist in the online realm, like teacher support and direct communication [19]. Little research has examined the relationship between students' choice of daily participation in HyFlex (face-to-face or remote) and self-regulation. Kohnke and Moorhouse [5] interviewed post-graduate students participating in a HyFlex instructional environment and found that students that participated remotely viewed class participation as "more tedious" than those participating face-to-face . This was partially due to the greater self-regulation required to complete course tasks and interact with their peers.

Purpose

Problem-centered learning experiences offered in a HyFlex format represent a complex learning environment. As students navigate modalities to participate in HyFlex environments, strong self-regulation skills can serve them well. Research suggests that some remote students are less engaged when participating in a HyFlex learning experience [7], which we hypothesize may be related to the increased need to self-regulate in remote environments. However, limited research has explored the relationship between how students chose to participate daily and self-regulation in HyFlex learning experiences. Therefore, we used the following question to guide this research: What is the relationship between students' self-regulation and their choice of daily participation in a HyFlex class?

Methods

HyFlex Course Environment and Participants

Design Thinking in Technology is a required introductory level course that uses a project-based approach to prompt learners to consider real-world problems through multiple individual

and team activities. Seventeen sections with a capacity of 40 students per section of the course were offered in the spring of 2022 using a flipped format, where all course content was shared with students prior to class time, and hands-on activities and discussions were facilitated during class meetings. Students completed three projects throughout the course. The first two group projects were designed to help students learn the design thinking process in-depth. The final group-based capstone project challenged students to apply what they have learned to address a real-world problem using the design thinking process to develop a functional prototype.

Prior to the COVID-19 pandemic, the course was delivered in a face-to-face format. Since then, the course has been offered in a synchronous HyFlex format, where students have the flexibility to join each class meeting synchronously remotely or face-to-face [7]. Microsoft Teams software was used during class to connect students who were face-to-face with those who were remote. Each team of students in class had their own Microsoft Teams channel which was often used outside of class for meetings and collaboration. The course was offered as HyFlex in the university's residential course catalog to accommodate residential learners who were unable to attend class physically on a temporary basis. Students were introduced to the HyFlex structure of the course through the syllabus, learning management software, and in-class conversations. All students were encouraged to attend face-to-face when practical and remotely as needed. As a routine, instructors created a calendar invite prior to each class session and started and recorded a Microsoft Teams meeting at the start of class. Students' attendance patterns were tracked for purposes of appropriately allocating course credit for team projects such that students in a group who did not participate did not earn credit. Students participating face-to-face and remotely were eligible to earn credit, while absent students are not. If a student was absent and unable to participate due to circumstances beyond their control, instructors typically suggested watching the recorded video and an alternative assignment to earn course credit.

RQ: What is the relationship between students' self-regulation and their choice of daily participation in a HyFlex class?

Data Collection and Analysis

The research team used a quantitative research design for the IRB approved study on students' HyFlex learning experience. In order to answer the research question, the Motivated Strategies for Learning Questionnaire (MSLQ) survey instrument developed by Pintrich [20] was used. The MSLQ has been cited by more than 14,000 studies as of 2023. The MSLQ includes two sections, motivation and learning strategies. The motivation section includes the value and expectancy component scales, and the learning strategies section includes the affective, cognitive and metacognitive strategies, and resource management scales. In all, the MSLQ contains 15 scales.

The original design of the MSLQ was modular, such that each scale may be used independently of the others [20] . As such, five scales were selected as they were the most appropriate for the course under investigation, as detailed below. The five scales used for this study and their associated Chronbach's Alpha measures of internal reliability are: control of learning beliefs ($\alpha = .68$), critical thinking ($\alpha = .80$), metacognitive self-regulation ($\alpha = .79$),

effort regulation (α = .69), and peer learning (α = .76). Control of learning beliefs are inherently intrinsic, in that, a positive outcome is directly attributed to one's effort, rather than by extrinsic means like a course instructor. In the design thinking course, if a student performed well by attending class face-to-face, they might continue doing so as long as it is having the desired effect. Students that apply critical thinking strategies are able to connect previous knowledge in new ways to develop solutions or make decisions while problem-solving. Design thinking is iterative and cyclical. As a result, learners in the design thinking course regularly make decisions based on knowledge gathered from previous work and offer solutions to defined problems.

Metacognitive self-regulation strategies are those that learners employ to plan, monitor, and regulate their awareness, learning, and cognition. Planning is when a learner analyzes a task in an effort to recall previous relevant knowledge to begin organizing learning material. When a learner monitors, they are tracking whether they are comprehending new information and seeing how it fits with prior knowledge. Finally, in the regulation stage, a learner is evaluating understanding and correcting behavior while they are working through the task. The design thinking course was broken into several formative tasks (assignments) that had a final outcome. Success on a task was contingent on the work that came before it. For instance, before a learner was able to define a problem, they needed to conduct an empathy interview. The learner must plan for who they will speak to and which questions they will ask. During the interview , students should determine if the interview is going as planned and, if it is, continue, if it is not, ask different questions or find someone else to interview. Effort regulation is one's ability to finish a task when faced with distractions or if the task is uninteresting. Due the amount of group work present in the design course, failure to complete an assignment or not give it full attention can impact the individual and the group. This may result in incomplete data analyses, missing solution ideas, or inadequate problem definitions. In a HyFlex environment, choosing to attend remotely for convenience-sake, could result in group communication issues or jeopardize one's sense of community. Lastly, peer learning was chosen due to the large amount of group work in the course. Dialogue between peers is beneficial for clarification purposes, it can help illuminate concepts missed by the individual, or help uncover insights not originally thought of.

Questions for each selected scale from the MSLQ were shared with 579 students as part of the end-of-semester course survey, which resulted in 331 responses. Attendance data of students were collected from each section's instructors. The class was scheduled to meet 29 times (roughly twice per week), and attendance data included the number of meetings students came physically to class (face-to-face), attended synchronously remotely, and the number of meetings for which each student was absent.

A ratio of attendance modality was calculated as a percent face-to-face to consider a correlation between choice of daily participation and self-regulation. This ratio was computed for each student by calculating the number of meetings attended face-to-face divided by the total number of meetings where a student participated (either face-to-face or remotely). Absences were excluded from the calculation, as the focus was on the decisions students made regarding which mode of participation (remote or face-to-face) was appropriate for them on a daily basis, as this course was traditionally a face-to-face course where HyFlex was introduced to maintain

participation during the pandemic. As an example, the resulting percent face-to-face value was 100% for students who were face-to-face exclusively (i.e., they were never remote and may or may not have had absences). As a second example, if a student was face-to-face for 24 meetings, remote for 3 meetings, and absent for 2 meetings, the student would have a percent face-to-face value of 24/(24+3) or 88.9%. Using the percent face-to-face and each of the five appropriate components/subcomponent of self-regulation, five Pearson correlations were calculated.

Results

Table 1

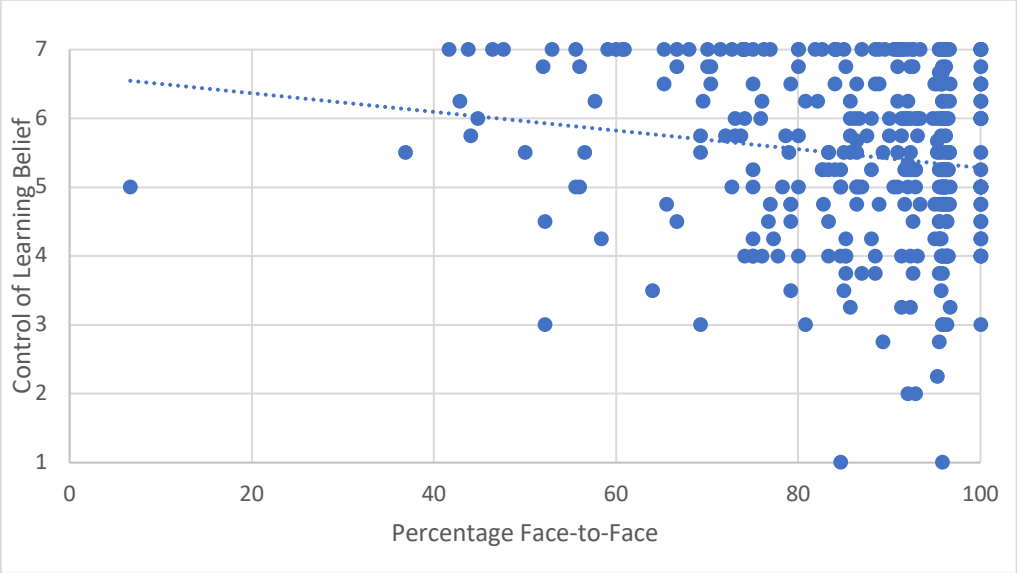
Summary of the Results

Self-Regulation	**Mean (Scale: 1=not at all true-7=very true)**	**Pearson Correlation (p)with students' Percentage face-to-face**
Control of learning beliefs	5.47	.005
Critical Thinking	5.09	.061
Metacognitive self-regulation	4.70	.134
Effort regulation	4.86	.773
Peer Learning	4.58	.716

Students' control of learning belief had a mean score of 5.47 with a range of 1 to 7. This indicates that students, on average, had a strong sense that their efforts would have positive outcomes such that they tend to agree with questions in the construct including: "If I try hard enough, then I will understand the course material". The Pearson correlation between students' percent face-to-face and their control of learning belief was significant and negative, $r(329) = -.15$, $p = .005$. Students who more frequently chose to participate face-to-face were associated with lower self-regulated control of learning belief. Or, conversely, students who more frequently chose to participate remotely were associated with higher control of learning belief regulation. The scatterplot of control of learning belief and percent face-to-face is shown in Figure 1.

Figure 1

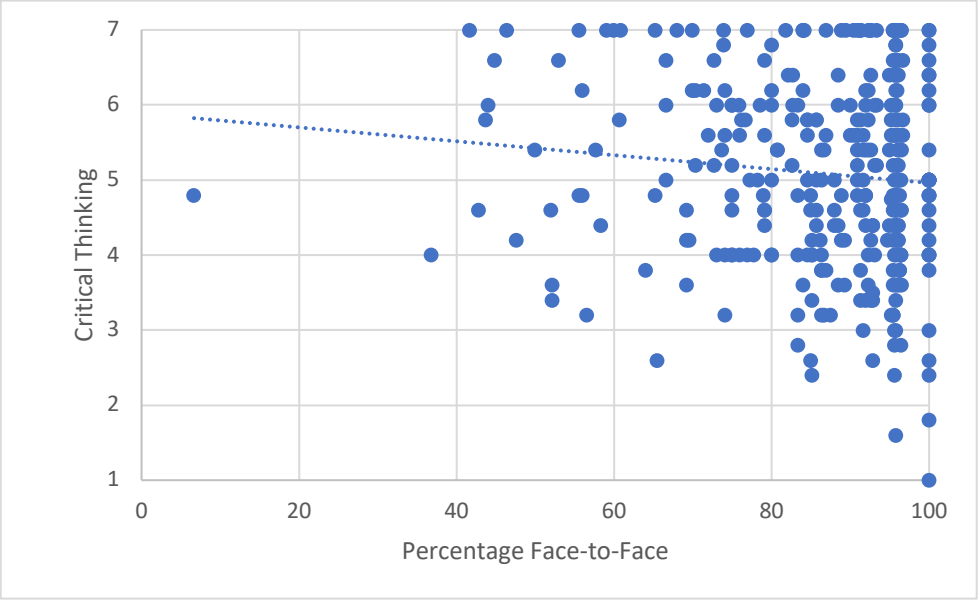
Control of Learning Belief and Percent Face-to-Face



Critical thinking had a mean score of 5.09 with a range of 1 to 7. This indicates that students, on average felt that it was true that they reported applying previous knowledge in their HyFlex class (see Figure 2). The Pearson correlation between students' percent face-to-face and their critical thinking was non-significant, $r(329)=-.103$, $p=.061$. Students who more frequently chose to participate face-to-face or remotely had a similar experience of applying previous knowledge in their course.

Figure 2

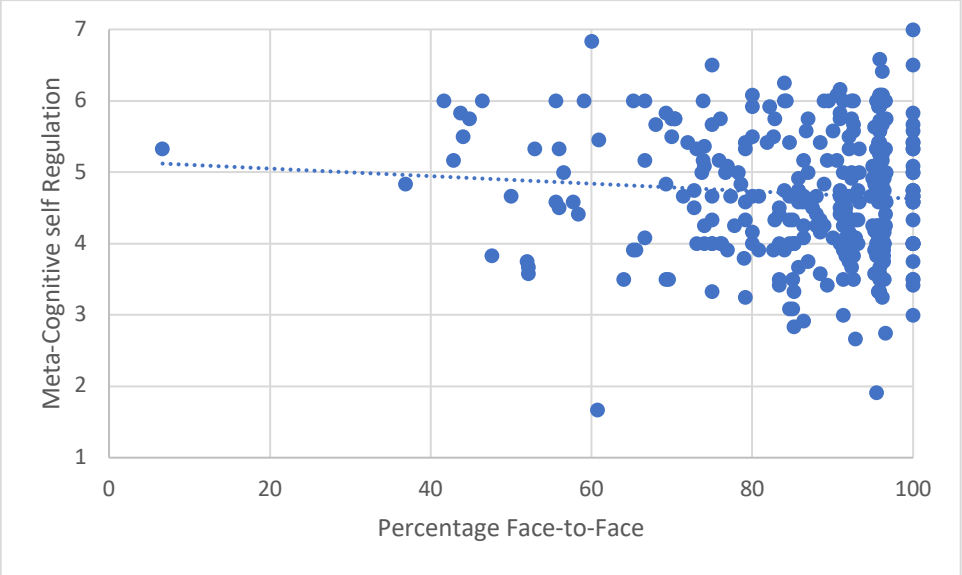
Critical Thinking and Percent Face-to-Face



Meta-cognitive self-regulation had a mean score of 4.70 with a range of 1 to 7. This indicates that students, on average, felt that it was somewhat true that they applied awareness, knowledge, and control of cognition in their HyFlex class (see Figure 3). The Pearson correlation between students' percent face-to-face and their critical thinking was non-significant, r(329)= -.083, p=.134. Students who more frequently chose to participate face-to-face or remotely had a similar experience of applying awareness, knowledge, and control of cognition.

Figure 3

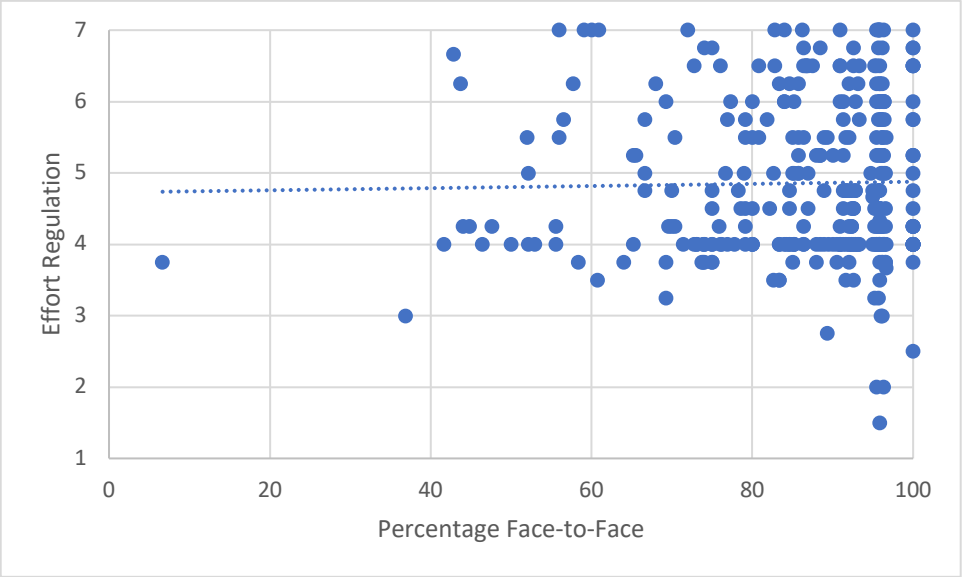
Meta-Cognitive Self-Regulation and Percent Face-to-Face



Effort regulation had a mean score of 4.86 with a range of 1 to 7. This indicates that students, on average, felt that it was somewhat true that they were able to control their effort and attention in their HyFlex class (see Figure 4). The Pearson correlation between students' percent face-to-face and their critical thinking was non-significant, r(329)= .019, p=.773. Students who more frequently chose to participate face-to-face or remotely had a similar experience of effort regulation.

Figure 4

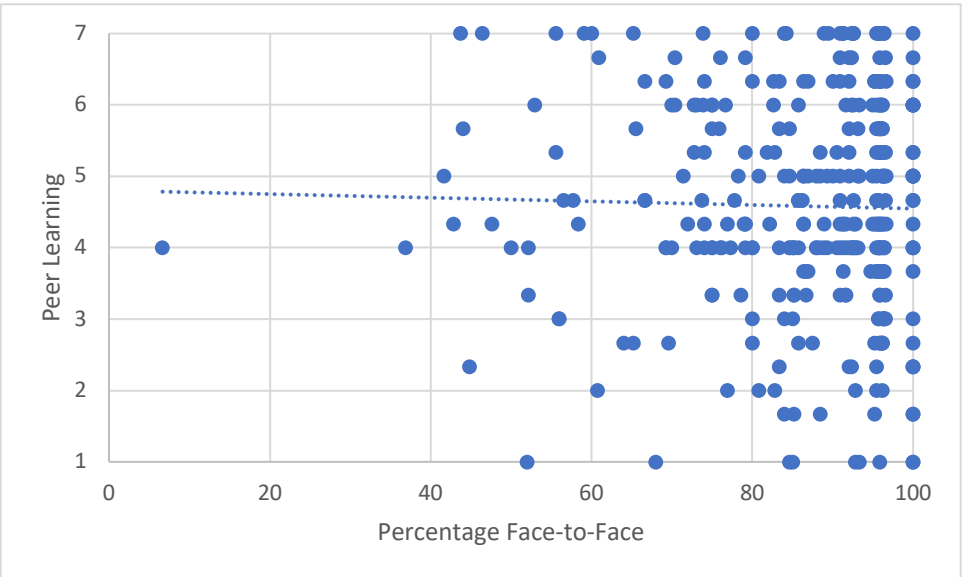
Effort Regulation and Percent Face-to-Face



Peer learning had a mean score of 4.58 with a range of 1 to 7. This indicates that students, on average felt that it was somewhat true that they were working and learning with peers in their HyFlex class (see Figure 5). The Pearson correlation between students' percent face-to-face and their critical thinking was non-significant, r(329)=-.020, p=.716. Students who more frequently chose to participate face-to-face or remotely had a similar experience related to peer learning.

Figure 5

Peer Learning and Percent Face-to-Face



Discussion

Engaging students in learning experiences is an ongoing challenge for educators. Creating highly flexible attendance policies where students can choose to be remote while their peers and teammates are in the classroom addresses a critical need for learning autonomy [21] but presents potential challenges related to engagement [7]. Students and instructors in the classroom who struggle to engage remote learners may have a sense that remote learners are less dedicated to learning and did not have the wherewithal to get into the classroom. However, these data indicate remote learners in a HyFlex environment have similar or higher levels of self-regulation as face-to-face learners. Thus, we suspect that while a few students may take advantage of the HyFlex environment and disengage as remote learners, the majority of students choosing to join remotely on occasion are making deliberate choices to continue engaging in learning.

The significant negative correlation between control of learning and percent face-to-face initially appears to be counter to complaints face-to-face peers and instructors have about remote students who are disengaged [7]. However, it may be that the majority of the students who are remote tend to be those who are unable to make it to the classroom and have a strong desire to remain engaged. Thus, while there may be a few students who do not have the self -regulation skills to navigate the remote environment, there may be a larger percentage of students who do attend class in person with low self-regulation skills. Having face-to-face peers and an instructor offering guidance may encourage students who have lower self-regulation to maintain the academic community. The other four strategies measured in this study (critical thinking, meta-cognitive, effort regulation, and peer learning) showed no significant correlations with students' ratios of participating face-to-face or remotely through the semester. Thus, a student's choice to attend remotely on one or more class meetings is unrelated to their ability to apply previous knowledge, have awareness and control of their own cognition, ability to control effort and attention, and sense of learning while working with peers.

Next Steps

These discoveries contribute to the potential for HyFlex learning approaches to become the new norm in collegiate pedagogical approaches. However, there are questions emerging from this investigation. Our investigation was motivated in part by our concerns about students choosing to be remote as a way of disengaging or potentially when remote, students are unable to contribute. While these data do not indicate students who are remote have any less self-regulation skills, that doesn’t explain our previous findings that indicated remote students struggle to contribute to their team’s work. Future investigation may consider the self-regulation of individuals at the team level to more clearly focus on team dynamics and how they function. Further, possibly, remote students who disengage are not welcomed by their face-to-face peers. After all, for a multimodal team of students to be functional, the face-to-face peers need to reach

out to the remote peers in addition to the remote peers reaching out to their face-to-face counterparts.

Our unique context is such that we are a residential campus offering a residential course as HyFlex. By default, we assume students will be in the classroom physically when possible, which aligns with the nature of our work with design projects. However, when students are remote or absent, we do not know why or what governs their choices. In other words, if the environment were not HyFlex, would the remote student be absent or face-to-face? By our course design and messaging, we prefer students to attend remotely instead of missing, and we prefer they be face-to-face when possible. Future study might investigate how students make decisions about course participation mode and their perspectives on peers who chose a different modality. Perhaps, most remote students are making very deliberate decisions for the benefit of their own learning while a few are taking the path of what appears to be least resistance, which is a detriment. Further research might discover what key factors are most helpful in guiding student decision making or instructor early warning signs related to the optimal modality on a given day.

These data were collected from the Spring 2022 academic term. While much of academia has returned to a near normal condition, impacts of the COVID pandemic may be lingering and first year students in this study may not have had "normal" secondary experiences to prepare them for college life and therefore repeating this study in future years may provide additional confirmation or insights.

As with any self-reported measure, students may knowingly or unknowingly introduce bias. To confirm these findings with greater understanding, a qualitative investigation may triangulate student self-reports with observations and interviews to shed light on students' dedication to learning and peer-to-peer interaction.

Appendix A: MSLQ Survey Questions for the Study

Scale: Likert 1- Not at all true of me to 7 very true of me

Control of Learning Beliefs - students' beliefs about their efforts resulting in positive outcomes (4)

1. If I work in appropriate ways, then I will be able to learn the material in this course
2. It is my own fault if I don't learn the material in this course
3. If I try hard enough, then I will understand the course material
4. If I don't understand the course material, it is because I didn't try hard enough

Critical Thinking - the degree to which students report applying previous knowledge (5)

5. I often find myself questioning things I hear or read in this course to decide if I find them convincing
6. When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decade if there is good supporting evidence
7. I treat the course material as a starting point and try to develop my own ideas about it
8. I try to play around with ideas of my own related to what I am learning in this course
9. Whenever I read or hear an assertion or conclusion in this class, I think about possible alternatives

Metacognitive Self-Regulation- the awareness, knowledge, and control of cognition (12)

10. During class time I often miss important points because I'm thinking of other things (REVERSED)
11. When working for this course, I make up questions to help focus my working
12. When I become confused about something I'm working for this class, I go back and try to figure it out
    a. Alternate: When I become confused about something I am working on for this class, I go back and try to figure it out
13. If course materials are difficult to understand, I change the way I read the material
    a. Alternate: If course materials are difficult to understand, I try to change the way I learn the material
14. Before I work on new course material thoroughly, I often skim it to see how it is organized

15. I ask myself questions to make sure I understand the material I have been working in this class
16. I try to change the way I work in order to fit the course requirements and instructor's teaching style
17. I often find that I have been working for class but don't know what it was all about (REVERSED)
    a. Alternate: I often find that I have been working on something for class but don't know what they were all about (REVERSED)
18. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when working
    a. Alternate: I try to think through the topic and decide what I am supposed to learn from it rather than just doing something
19. When working on something for this course I try to determine which concepts I don't understand well
20. When I work on something for this class, I set goals for myself in order to direct my activities in each work period
21. If I get confused taking notes in class, I make sure I sort it out afterwards

Effort Regulation- students' ability to control their effort and attention (4)

22. I often feel so lazy or bored when I work on something for this class that I quit before I finish what I planned to do (REVERSED)
23. I work hard to do well in this class even if I don't like what we are doing
24. When coursework is difficult, I give up or only work the easy parts (REVERSED)
25. Even when course materials are dull and uninteresting, I manage to keep working until I finish

Peer Learning- beliefs about learning regarding working with peers (3)

26. When working on something for this course, I often try to explain the material to a classmate or a friend
27. I try to work with other students from this class to complete the course assignments
28. When working on something for this course, I often set aside time to discuss the course material with a group of students from the class

References

[1] B. Beatty, *Hybrid-Flexible Course Design*. EdTech Books, 2019. Accessed: Feb. 13, 2023. [Online]. Available: https://edtechbooks.org/hyflex

[2] G. Heilporn and S. Lakhal, "Converting a graduate-level course into a HyFlex modality: What are effective engagement strategies?," *Int. J. Manag. Educ.*, vol. 19, no. 1, p. 100454, Mar. 2021, doi: 10.1016/j.ijme.2021.100454.

[3] S. Lakhal, D. Bateman, and J. Bédard, "Blended Synchronous Delivery Modes in Graduate Programs: A Literature Review and How it is Implemented in the Master Teacher Program," *Collect. Essays Learn. Teach.*, vol. 10, pp. 47–60, Jun. 2017, doi: 10.22329/celt.v10i0.4747.

[4] B. Beatty, "Hybrid Courses with Flexible Participation: The HyFlex Course Design," *Practical Applications and Experiences in K-20 Blended Learning Environments*, 2014. https://www.igi-global.com/chapter/hybrid-courses-with-flexible-participation/www.igi-global.com/chapter/hybrid-courses-with-flexible-participation/92972 (accessed Feb. 13, 2023).

[5] L. Kohnke and B. L. Moorhouse, "Adopting HyFlex in higher education in response to COVID-19: students' perspectives," *Open Learn. J. Open Distance E-Learn.*, vol. 36, no. 3, pp. 231–244, Sep. 2021, doi: 10.1080/02680513.2021.1906641.

[6] P. Calafiore and E. Giudici, "HYBRID VERSUS HYFLEX INSTRUCTION IN AN INTRODUCTORY FINANCE COURSE.," *Int. J. Educ. Res.*, vol. 16, no. 1, pp. 40–52, Sep. 2021.

[7] N. Mentzer and L. Mohandas, "Student experiences in an interactive synchronous HyFlex design thinking course during COVID-19," *Interact. Learn. Environ.*, vol. 0, no. 0, pp. 1–16, Sep. 2022, doi: 10.1080/10494820.2022.2124423.

[8] B. C. Padilla Rodriguez, "The Rise and Fall of the HyFlex Approach in Mexico," *TechTrends*, vol. 66, no. 6, pp. 911–913, Nov. 2022, doi: 10.1007/s11528-022-00780-3.

[9] J. Penrod, "Staying Relevant: The Importance of Incorporating HyFlex Learning into Higher Education Strategy," 2022. Accessed: Feb. 13, 2023. [Online]. Available: https://er.educause.edu/articles/2022/3/staying-relevant-the-importance-of-incorporating-hyflex-learning-into-higher-education-strategy

[10] E. Howell, "HyFlex model of higher education: understanding the promise of flexibility," *Horiz. Int. J. Learn. Futur.*, vol. 30, no. 4, pp. 173–181, Jan. 2022, doi: 10.1108/OTH-04-2022-0019.

[11] R. A. Rasheed, A. Kamsin, and N. A. Abdullah, "Challenges in the online component of blended learning: A systematic review," *Comput. Educ.*, vol. 144, p. 103701, Jan. 2020, doi: 10.1016/j.compedu.2019.103701.

[12] M. M. M. Abdelmalak and J. L. Parra, "Case Study of HyFlex Course Design: Benefits and Challenges for Graduate Students," *Innovative Applications of Online Pedagogy and Course Design*, 2018. https://www.igi-global.com/chapter/case-study-of-hyflex-course-design/www.igi-global.com/chapter/case-study-of-hyflex-course-design/203941 (accessed Feb. 13, 2023).

[13] J. Miller, “Student Choice, Instructor Flexibility: Moving Beyond the Blended Instructional Model,” *Issues Trends Educ. Technol.*, vol. 1, Jan. 2013, doi: 10.2458/azu_itet_v1i1_miller.
[14] B. J. Zimmerman, “A social cognitive view of self-regulated academic learning,” *J. Educ. Psychol.*, vol. 81, pp. 329–339, 1989, doi: 10.1037/0022-0663.81.3.329.
[15] B. J. Zimmerman and D. H. Schunk, *Handbook of Self-Regulation of Learning and Performance*. Routledge, Taylor & Francis Group, 2011. doi: 10.4324/9780203839010.
[16] T. J. Cleary and B. J. Zimmerman, “Self-Regulation Empowerment Program: A School-Based Program to Enhance Self-Regulated and Self-Motivated Cycles of Student Learning,” *Psychol. Sch.*, vol. 41, pp. 537–550, 2004, doi: 10.1002/pits.10177.
[17] E. De Corte, L. Verschaffel, and P. Op’t Eynde, “Self-regulation: A characteristic and a goal of mathematics education,” in *Handbook of self-regulation*, San Diego, CA, US: Academic Press, 2000, pp. 687–726. doi: 10.1016/B978-012109890-2/50050-0.
[18] S. Van Laer and J. Elen, “In search of attributes that support self-regulation in blended learning environments,” *Educ. Inf. Technol.*, vol. 22, no. 4, pp. 1395–1454, Jul. 2017, doi: 10.1007/s10639-016-9505-x.
[19] M. F. Kashif and R. Shahid, “Students’ self-regulation in online learning and its effect on their academic achievement.” Glob. Educ. Stud. Rev. VI, 11-20., 2021.
[20] P. R. Pintrich and A. Others, “A Manual for the Use of the Motivated Strategies for Learning Questionnaire (MSLQ),” 1991. Accessed: Feb. 13, 2023. [Online]. Available: https://eric.ed.gov/?id=ED338122
[21] N. Mentzer, B. Krishna, A. Kotangale, and L. Mohandas, “HyFlex environment: addressing students’ basic psychological needs,” *Learn. Environ. Res.*, Oct. 2022, doi: 10.1007/s10984-022-09431-z.