The Synchronicity Paradox in Online Education

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ABSTRACT
As online education proliferates, one concern that has been raised is that it may fail to capture desirable emergent phenomena from on-campus programs. Student community is one example of such a phenomenon: on-campus student communities thrive based on synchronous collocation. An online program might be designed to capture all deliberate constructs in an on-campus program, but there may be beneficial side effects of synchronous collocation that are not apparent. In this work, we examine the issue of social isolation in an online graduate program. By happenstance, three studies were conducted in relative isolation looking at social isolation from different angles. The first study examined trajectories in social presence as a semester proceeded. The second study developed an understanding of students' needs with regard to community in an online program. The third study tested out an immersive virtual environment to try to improve students' sense of connectedness. Combining their findings, we find compelling evidence of the existence of a Synchronicity Paradox in online education: students desire synchronicity to form strong social communities, and yet part of the chief appeal of these online programs is their asynchronicity. In light of this finding, we provide design guidelines for how synchronicity may be reintroduced into asynchronous programs without sacrificing the benefits of asynchronicity. More specifically, we propose that scale itself may be the key to building emergent synchronicity.

Author Keywords
Online education; social presence; student communities; affordable degrees at scale.

CCS Concepts
•Applied computing~Education
•Applied computing~Collaborative learning
•Applied computing~Distance learning

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INTRODUCTION
Over the past ten years, scalable online educational programs have grown tremendously [2], beginning with MOOCs [20] and continuing with affordable degrees at scale [12][22]. Though these programs' affordability draws headlines, they have other distinct features: they are typically geographically distributed and asynchronous [15]. This structure contrasts with older online offerings that require synchronous tele-attendance of a live lecture or infrequent in-person attendance for examinations.

The online, distributed, asynchronous nature of at-scale programs demands that we investigate whether emergent properties of traditional programs also emerge online, such as social communities of students. While classes may not design such communities, they are part of traditional educational programs [18]. Research shows online courses tend to have higher attrition specifically due to the loss of interaction with a broader student community [1][8][21][27].

As geographic distributedness and asynchronicity become more common in higher education, students risk becoming isolated and disconnected from peers [1][3][17]. Thus, we must investigate the determinants of that sense of isolation. Once we know what generates feelings of isolation and connectedness, we can move toward constructing online learning environments that address those determinants.

In this work, we report three studies conducted on a large, affordable online graduate program. While the studies examine the same population, they were conducted by different researchers with different goals: one investigated students' sense of social presence on its own; one sought to design solutions to support student communities; and one evaluated an interface designed to support camaraderie. The three studies and their differing objectives provide a multifaceted picture of student isolation online. One particularly notable factor emerges: students desire synchronicity, but asynchronicity is a major part of the program's appeal.

RELATED WORK
Significant prior work has been conducted on student communities, especially in online education. Among the earlier studies, Ouzts [19] found patterns regarding poor sense of community. This was attributed in part to the teacher themselves rather than to course design. Courses that created strong communities were those in which an instructor was engaged and those in which there were opportunities for peer-to-peer interaction. This suggests that community formation required an "anchor" for communication.

Shea [23] analyzed online student communities using the Community of Inquiry model; this model is the foundation for the inventory of social presence we use in this work [25]. Shea similarly found that active participation from the instructor was a strong determinant of a sense of "shared purpose, trust, connectedness, and learning" in the community of learners. Shea also found that women experienced a greater sense of community than their male classmates.

Those studies, both published in 2006, point to the role of the instructor in facilitating a positive student community. This poses a potential challenge for the more recently-emergent degrees at scale, where the instructor:student ratio is far higher (although teaching assistants, if counted as instructors, may drive that ratio down to more typical levels). However, it may be the case that in these at-scale programs, a different trend takes hold; scale itself may facilitate the emergence of a student community even in the absence of a deliberate design by an instructor. Joyner, Goel & Isbell [13] posit this development as among the "unexpected" benefits of scaling degree programs. They note that student activity is far higher in these large classes, allowing a student community to develop more emergently. These studies have not, however, yet identified whether the perceived activity of these student communities is translating into an increased sense of connectedness, presence, and community.

Other work has more directly examined the effects of isolation on retention and success rates in higher education. Ali and Smith find higher withdrawal rates in online courses than face-to-face courses, which they attribute in part to the lack of student community [1]. Frankola [8] found that the "loneliness" of cyberspace contributes to online learners' decision to drop out. Willging & Johnson [27] similarly find that difficulty making friends predicts likelihood to drop out of an online course. Rovai & Wighting [21] found poor classroom communities are associated with increased rates of alienation, and advocated that classroom activities be introduced that specifically foster greater community and connectedness among learners. Significant research attention has also been devoted to the intersection between MOOCs, social isolation, and attrition [4][6][5][24] as well; however, we are hesitant to overgeneralize these findings to for-credit programs given the differential barriers to entry, costs of attendance, and rewards for completion.

Despite all this related literature, however, one additional component stands out: a significant portion of the prior research on isolation in online education was performed in the relatively early days of online learning. The consensus that online learning is isolating took hold prior to the mainstream emergence of social media and online communities. It may be argued that the isolation was due in part to a general lack of familiarity with the new environment, and that modern audiences may find the online context more welcoming based on their familiarity with other online communities. Thus, in addition to seeking ways to improve students' sense of social presence and connectedness online, we must question our assumptions that feelings of isolation are inherent to the environment.

RESEARCH CONTEXT

This research takes place in the context of a large, asynchronous online graduate program in computer science. A full description of the program's background is out of scope for this analysis, but can be found in existing literature on the program [14][15]. For this paper, there are a few pertinent contextual details about the program's student body and the type of asynchronicity it employs.

Program Context

First, the student body for this program is over 8,500 students as of Spring 2019. The average class size in Spring 2019 was 396, with nine classes enrolling over 500 students. Over 2/3rds of the program's classes are project-based, many requiring group projects. Students are in their mid-30s on average, and 65% reside in the United States. The vast majority of students in the program are simultaneously working full time. A small number of participants in Study #2 may also come from two of the program's sister programs, with which the program shares some classes.

In terms of the research that follows, these characteristics support and discourage social connections in different ways. On the one hand, the competing family and work obligations limit the time students have to invest in activities that do not have an immediate pay-off. It has been argued also that because they are older and thus began using social media later in life, they may not be as comfortable with these tools as younger audiences (a hypothesis our research will refute). On the other hand, the scale of the program dictates that there is a student body to search to find those with criteria in common; for example, while fewer than a half-percent of students in the program reside in Singapore, there were nonetheless 45 students from Singapore in the program in Fall 2019.

Finally, as noted previously, the three studies presented in this analysis were pursued by different researchers during different terms. Their order below reflects the best narrative for understanding the findings, but the studies were actually performed in Spring 2019 (Study #3), Summer 2019 (Study #1), and Fall 2019 (Study #2). Analyses of each study were not completed until after data gathering for the subsequent studies had concluded, and thus these studies did not largely influence one another. Their corroboration of one another is thus stronger than if they had been pursued in sequence or by the same researchers.

Spectrum of Synchronicity

Because this study examines synchronicity, it is also important to briefly articulate our definition of the term. We observe that there is a spectrum of synchronicity, from purely self-paced always-open MOOCs to traditional courses featuring live lectures. Synchronicity may refer to whether there are individuals following the same schedule

(which we will call 'cohort synchronicity') or it may refer to whether students interact live (which we will call 'interactional synchronicity'). Here, we are concerned with interactional synchronicity: students in this program follow a shared schedule with common deadlines but lack any required live interaction.

STUDY #1: SOCIAL PRESENCE IN ONLINE EDUCATION

The first study targeted student presence most deliberately. The goal of this study was to directly understand the student social experience from a researcher perspective.

Methodology

In Study #1, researchers created a survey to explore students' sense of social presence. This survey included a validated inventory of social presence [25][26]. The social presence inventory asked nine 5-point Likert-scale questions, and students' social presence scores were calculated as the average of their answers to those questions. In this way, a score of 3 indicates a person who is neither highly connected nor highly disconnected, while a score of 1 represents a highly disconnected individual and a score of 5 represents a highly connected individual. Table 3 shows the specific prompts that students were asked to agree or disagree with. The survey also asked several questions reflecting on students' specific desires (e.g. "Do you want to connect more with other students in the online program?").

This survey was distributed in four different classes, and in each class it was distributed four times to monitor for trends as the semester progressed. These distribution dates were at weeks 1, 5, 9, and 17. Completion of these surveys contributed to students' participation grades in each of the classes, although this credit could be earned through other mechanisms as well; thus, participation was compensated but not required. Table 1 below shows response rates for each class and survey. Due to limitations in the learning management system used to export survey data, only students who completed the class are included in these numbers; students who withdraw from a class have their data immediately removed from survey exports.

Table 1: Response rates for the four surveys in the four classes.

	Survey 1	*Survey 2*	*Survey 3*	*Survey 4*
Class 1	168/168 (100%)	142/168 (84.52%)	140/168 (83.33%)	117/168 (69.64%)
Class 2	410/434 (94.47%)	377/434 (86.87%)	356/434 (82.03%)	288/434 (66.36%)
Class 3	385/411 (93.67%)	330/411 (80.29%)	317/411 (77.13)	263/411 (63.99%)
Class 4	642/929 (69.11%)	571/929 (61.46%)	573/929 (61.68%)	485/929 (52.21%)

Table 2: Distribution based on age and gender on each of the course surveys.

	Survey 1	*Survey 2*	*Survey 3*	*Survey 4*
Female	312	288	274	219
Male	1281	1123	1104	928
Other	1	1	1	0
Prefer not to say	10	7	6	5
Age 18 to 24	194	177	172	134
Age 25 to 34	994	875	854	712
Age 35 to 44	324	287	283	239
Age 45 to 54	77	68	65	56
Age 55 to 64	14	11	10	10

To understand the demographics under investigation, we further broke down these survey results by age and gender regardless of class, shown in Table 2. These breakdowns are important to Study #1 as it aims to isolate not only trends in social presence, but also how those trends differ based on gender and age.

Results

Our analysis first looked for trends in social presence scores [25] as the semester progressed, broken down by gender and age. We found no notable trends in this area, however. Regardless of age or gender, students entered each class with a social presence score of approximately 3.8, indicating a moderately positive sense of social presence. These scores did not vary significantly across the semester; deviations from original scores were all within two-tenths of a point and were not statistically significant within any subpopulation. We thus find no basis for age- or gender-specific differences in social presence, nor a longitudinal effect based on one's experience within a class.

For our remaining analyses, then, we look only at each class's first survey to avoid overrepresenting students who are more likely to respond to more than one survey. Table 3 shows the specific prompts, as well as the average score on each prompt on the first surveys given in each class.

We note the higher scores are associated with the prompts that are a bit more "passive", such as "I felt comfortable conversing through the online medium", and students are a bit more lukewarm on the more "active" prompts. Combining this observation with a rather lukewarm overall score of 3.72 on average, we find that while students do not feel actively disconnected from the class, they do not appear to feel particularly connected either.

Table 3: Statements offered to students to measure their level of social presence, based on [25], and the average response out of 5 to each prompt on the first survey.

Prompts from the Social Presence Component of the Community of Inquiry Instrument	*Avg. Agreement*
Getting to know other course participants gave me a sense of belonging in the course.	3.59
I was able to form distinct impressions of some course participants.	3.51
Online or web-based communication is an excellent medium for social interaction.	3.45
I felt comfortable conversing through the online medium.	4.00
I felt comfortable participating in the course discussions.	3.91
I felt comfortable interacting with other course participants.	3.94
I felt comfortable disagreeing with other course participants while still maintaining a sense of trust.	3.62
I felt that my point of view was acknowledged by other course participants.	3.71
Online discussions help me to develop a sense of collaboration.	3.79

Turning to the other questions, we asked students about their interest in and ability to connect with others. These were asked on each of the four surveys, but we again saw no longitudinal trends. We thus select only the start-of-course survey for further analysis.

Figure 1 shows the breakdown based on gender. A statistically significant difference ($\alpha = 0.01$) was observed based on gender in agreement with the first sentiment ($z = 2.526$, $p = 0.0014$); women were more likely to be interested in connecting with others in the program than men. We found no significant difference in ease of connecting, however. This desire corroborates the similar finding by Shea [23].

We then also broke these responses down by age, shown in Figure 2. We performed hypothesis tests dividing students into two groups, over and under 35 years old, to balance populations. We see a statistically significant ($\alpha = 0.01$) difference in interest in connecting with others, as 77.1% of the 415 students 35 and over expressed interest in connecting, compared to 70.3% of those under 35 ($z = 2.6654$, $p = 0.0077$). We see a similar difference in difficulty; students 35 and over report greater ease (81.2%) in connecting than students younger than 35 (74.2%) with statistical significance ($z = 2.8608$, $p = 0.0042$). Thus, older students are more interested in and more able to form connections than younger students. This is noteworthy given the perceived greater ease with which younger students interact online.

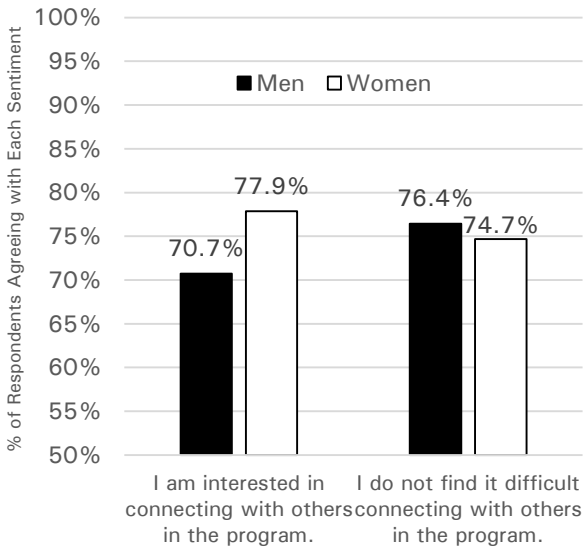

Figure 1: Gender differences in level of agreement with prompts about whether students want to connect with others and find it easy to connect with others. On the second prompt, students were given the question, "Do you find it difficult to connect with others?"; percentage shown are those who answered 'No'.

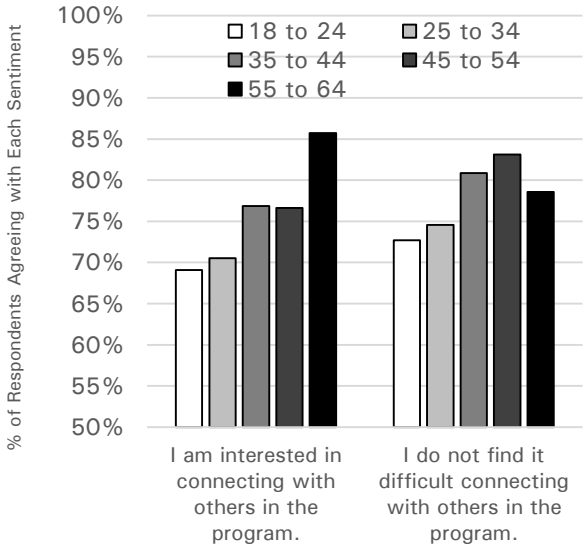

Figure 2: Age-based differences in level of agreement with prompts about whether students want to connect with others and find it easy to connect with others.

We note here that, similar to the social presence inventory, the results of this survey are up to the students' interpretation of the term "connecting". Do students interpret this as forming lasting relationships, or merely making an initial connection? Combining this with the prior results on social presence, we find the question of student isolation remains open. Students' sense of connectedness is not obviously high, nor is it absent. Further exploration is necessary.

STUDY #2: NEEDFINDING TO SUPPORT COMMUNITY

While the first study targeted understanding students' social presence from a research perspective, the second study was a needfinding exercise to inform the design of new interfaces to support the student community. While this examined many of the same questions, it also added on a component of "why" students feel the way they do, in order to inform the design of new student experiences. Notably, it also brought in the perspectives of teaching assistants (who function as both students and staff) and faculty members.

Methodology

Study #2 consisted of a survey and a set of semi-structured interviews. 127 students participated in the survey, recruited from various class forums and program-related social media boards. 21 people participated in the interviews, including 11 students, 5 teaching assistants, and 5 faculty members. The design of the surveys and interview questions was informed by a prior round of observational research examining trends in posting patterns on class forums, student conversations on social media, and literature on similar programs. Table 4 shows a subset of the survey and interview questions that were asked.

In addition to these questions, students were also offered the chance to expand on their answers in open-ended free-response boxes. They also answered a handful of yes/no questions, such as "Is the fear of violating the honor code one of the main factors stopping you from creating or participating in study groups?", and some questions asking for more categorical answers, such as, "What type of connections are you looking to make in the program? {Social acquaintances / Class-specific study partners / Long-term/multi-class study partners / Professional acquaintances / Other; please specify}".

Results

Looking at the survey results, 42.5% of students reported feeling at least somewhat isolated (that is, answering 5, 6, or 7 to the question, "I feel isolated in the program."). More interestingly, though, there was a strong correlation ($r = 0.87$) between the number of classes a student had completed and their reported level of isolation. Figure 3 shows this trend; while only around 20% of new students (0 or 1 classes completed) reported feeling isolated, 85% of more seasoned participants reported that perception. This finding is counter-intuitive, as we might suspect that students who feel connected are more likely to persist or that given greater time, students form more connections. Instead, it appears that time spent in the program leads to an increasing sense of isolation, perhaps as relationships form and break across different classes over time; this hypothesis is suggested by one interview comment, "I had a good level of friendship with my [class] group project teammates ... that got broken because we're now enrolled in different subjects." An alternative less compelling hypothesis is that students who enrolled 2-3 years ago were substantially different from new enrollees now, and sense of isolation is a function of matriculation date rather than duration in the program so far.

Table 4: Selected questions asked during the needfinding survey in study #2.

Question/Prompt	*Type*
I find it difficult to have back and forth conversations with my peers. I feel isolated in the program. The only way I would want to connect with my peers is through academic activities. I feel intimidated to create a post on Piazza that will be seen by a large number of people. I feel intimidated to send a message on Slack that will be seen by a large number of people.	7-point Likert-scale: 1. Strongly Disagree 2. Disagree 3. Slightly Disagree 4. Neither Agree nor Disagree 5. Slightly Agree 6. Agree 7. Strongly Agree
How **important** is it to you to interact with peers in real-time? How **interested** would you be in being a part of a small group of peers in a class, automatically created based on similar personalities and interests? How **interested** would you be in being a part of a small group of peers in a class, automatically created to seek quick help (should you want it) based on who's online? How **interested** would you be in being a part of a small group of peers in the OMSCS program, automatically created based on when you joined the program? How **interested** would you be in being a part of a small group of peers in the OMSCS program, automatically created based on similar personalities and interests? How **interested** would you be to watch the lecture videos with other students at the same time and discuss the content? How **comfortable** would you be in using voice chat to interact with your peers? How **comfortable** would you be in using video chat to interact with your peers?	5-point Likert-scale: 1. Not at all {important / interested / comfortable} 2. Slightly {important / interested / comfortable} 3. Somewhat {important / interested / comfortable} 4. Moderately {important / interested / comfortable} 5. Extremely {important / interested / comfortable}

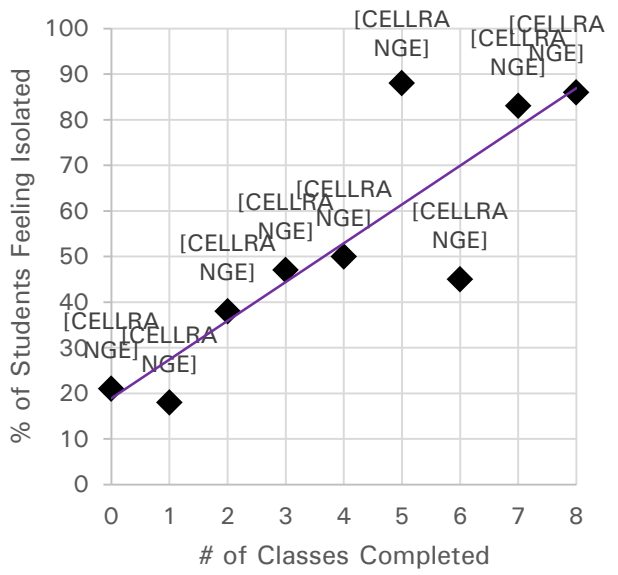

Figure 3: Percentage of students selecting 5, 6, or 7 in agreement with "I feel isolated in the program" based on number of classes taken. Numbers alongside data points show the number of respondents selecting that number of classes completed; for instance, 8 respondents reported completing 5 classes, and 87.5% (7 of the 8) selected that they felt isolated.

The vast majority (88.9%) of respondents to the survey similarly noted that they are looking to form more connections. 63.7% of respondents further specifically wanted more ways to connect with peers apart from academic activities. We thus turn our attention to what may make the process of forming social relationships different in the online program compared to in person, especially the role of colocation and synchronicity. A small majority (54.0%) of respondents noted that they found it "not at all" important to meet them in-person to become connected; this is compatible with part of the program's appeal, its geographic distributedness. Only a small minority (8.7%) reported similarly that real-time communication is unimportant, suggesting a potential fundamental mismatch between the appeal of the program and the shared temporal context needed for forming social relationships. More students (31.1%) also reported feeling more intimidated to post on an asynchronous forum than in a live chat tool (14.4%) in part due to the transient nature of real-time communication. One student commented, "[The forum] feels like I'm shouting to 200 people. It's intimidating to jump in and participate. I don't want to be wrong, so I don't post."

Students were also asked what factors most significantly hindered their ability to form connections, and the most common answer (46.5%) was a lack of time; this is unsurprising given prior notes about the demographics of the student body and the prevalence of competing work and family obligations. The other most common reasons were a desire to find people in similar locations (15.2%, from the minority of students who found in-person connections important to forming social relationships) and a lack of informal or small group activities in which to participate to form these relationships (16.8%). This last reported cause is particularly actionable, as it echoes the need for shared activities through which to form social relationships. For example, one student mentioned in an interview, "During group projects in 3 courses I felt very connected to my peers - despite never meeting them in person."

For the most part, findings from the interviews echo and elucidate these survey findings; in some places, the interviews provided additional context for why isolation may arise as well. One student commented that "I'm likely to be friends with someone who has a user profile over someone who's anonymous." This suggests that online isolation may be addressed in part by increasing the bandwidth with which students can communicate passively with one another. Reflecting on their undergrad experience, another student commented, "It was easy to run into people!", suggesting a need for more environments in which non-deliberate interactions can occur.

Overall, these findings further suggest that the isolation that may arise is connected to one of the fundamental appeals of the program itself: its asynchronicity. In other places, it is evident that we may be able to design experiences that reduce that isolation by focusing on small groups with clear anchors for interaction.

STUDY #3: DESIGN-BASED RESEARCH ON IMMERSIVE SOCIAL ENVIRONMENTS

Study #3 hypothesized the existence of many of the trends that Study #2 went on to discover, but rather than investigating them directly via surveys and interviews, it adopted a design-based research approach. In Study #3, we developed an environment that would provide to students synchronous, "colocated" settings in which to interact via an immersive virtual environment. These environments were structured to mimic common classroom contexts, like lecture halls, student lounges, and professors' offices. Through this study, we sought to understand whether students valued these constructs by observing their usage thereof.

Study #3 actually took place prior to Study #2; the order of these studies in this paper is intended to provide a narrative, but Study #3 was conducted prior to and by different researchers than Study #2.

Methodology

Study #3 consisted of five studies, including a survey regarding prior beliefs, three usability studies with a virtual social lounge, poster session, and lecture hall, and a controlled experiment with a virtual lecture hall. In all studies, students were recruited from one of four classes and offered class participation credit for completing the survey participating in the study. For the three usability sessions, students gave feedback about their participation in a single session. For the controlled experiment, they were randomly assigned

to one of three groups: the virtual environment (synchronous and virtually colocated), a synchronous chat tool (synchronous, not colocated), or an email discussion group (neither synchronous nor colocated) and participated in a watching activity with prerecorded lectures and no instructor presence for three consecutive weeks before reflecting on their experience.

Most of the findings from Study #3 are outside the scope of this analysis. This description only covers those relevant to the general issue of students' sense of isolation in online classes.

Results

The survey study on prior beliefs examined students' perceptions of virtual reality, their sense of isolatedness, and their likelihood to use specific synchronous and virtually colocated environments. 208 students participated. 42% of participants disagreed (a response of 1, 2, or 3 on a 7-point Likert scale) that they felt connected to their classmates, while only 30% agreed (28% were neutral). Many noted it was a priority, however, as 59% agreed with the statement "I need to be able to interact with my classmates when taking online classes" and 67% agreed with a statement that they wanted to interact more than they presently do. Interestingly, students actually reported a surprisingly large amount of existing interaction as well: 11% reported interacting with classmates at least daily and 36% at least weekly, a volume that likely is mirrored in an on-campus environment. This suggests that isolation is not a product merely of a low volume of interaction, but something more complex regarding the quality or substantivity of the interaction. Alternatively, it may be that on-campus and online audiences feel comparably isolated.

In the survey, we also provided descriptions of three different synchronous and virtually colocated environments we intended to design: a virtual lecture hall, virtual office hours, and virtual social lounges. We asked students to rate on a scale of 1 to 4 (Would Not Try; Might Try, Would Not Use Regularly; Would Try, Might Use Regularly; Would Use Regularly) their likelihood to use the interface. More than 85% reported they would at least try each interface; approximately 50% reported they would or might use the virtual lecture hall and virtual social lounge regularly, while 68% reported they would or might use the virtual office hours environment regularly. We hypothesize this last value is due in part to students' desire for greater interaction with instructors, but the interest of 50% of the respondents in synchronous and virtually colocated environments for socializing or watching lectures indicates to us a specific interest in this type of interaction.

Later, we recruited participants to test the three environments (as well as a fourth we added, virtual poster sessions). For the virtual lecture hall, we conducted two tests: an exploratory usability study and a controlled experiment. Students participating in the exploratory session were asked to watch a lecture with between 6 and 12 classmates in most sessions, then report on their experience. Students could participate multiple times, and so we separate analysis by early sessions (44 total participants) and late sessions (22 participants), where early sessions draw almost exclusively first-time users and late sessions draw more repeat users. 63% of early session users reported that they felt connected to their classmates, although nearly half (47%) also reported that it did not improve their overall lecture-watching experience and that it distracted them from the lecture content. 86% reported they would re-watch the lecture later. These numbers diminished for late session users, where only 50% agreed they felt more connected but only 10% reported feeling distracted, suggesting social norms or comfort with the technology had set in. Nonetheless, 84% of early session attendees and 96% of late session attendees reported they would like to attend sessions again in the future.

In the controlled experiment, students were randomly assigned to use one of three environments to watch lecture material in three consecutive weeks. 29 students used the virtual lecture hall (synchronous and virtually colocated) in groups of ~8; 32 students used a synchronous chat tool (synchronous, but not colocated) in groups of ~8; and 31 students held an email discussion after watching each week's lectures on their own (neither synchronous nor colocated) in groups of ~8. At the end of the three weeks, students reflected on the experience and were asked to rate their agreement on several statements. For the statement "The lecture-watching activity improved my sense of connectedness to my classmates", more students in the synchronous chat group (65%) agreed, compared to 52% for the email group and 45% for the virtual lecture hall group. The synchronous chat group similarly outperformed the other two on statements like, "Getting to know other course participants gave me a sense of belonging in the course.", "I would participate in this activity in the future if it was awarded participation credit." and "I was able to form distinct impressions of course participants." Nonetheless, all three conditions rated relatively equally on whether students would participate in the activity if participation credit was not offered (41% or 42% for all three conditions).

There are, of course, many lurking variables in these trends. The virtual lecture hall environment was technologically more demanding than the synchronous chat or email discussion tools, and students regularly reflected on having difficulties with accessing the rooms; these effects likely mitigated any potential advantages that could be derived from the tool. In the context of the prior two studies, however, the primary takeaway here is the value that students continue to place on synchronicity. Despite already communicating with classmates at a relatively high volume, students expressed the desire for more connection; reflected positively on environments that would foster synchronous interaction; and reported more positive experiences from a tool that delivered synchronous communication compared to one delivering asynchronous interaction.

DISCUSSION

Our discussion of these results covers three areas: first, we will endeavor to synthesize the varying observations of the prior studies. Second, we will note the limitations, especially to generalizations. Third, we will discuss the design implications of these findings.

Synthesis

The above three studies targeted the same underlying phenomenon from different angles. All three are interested in the extent to which students in an asynchronous, distributed, online, for-credit program feel either isolated or socially connected. Study #1 examines this phenomenon directly using an inventory for social presence as well as several statements asking students to reflect on their level of connectedness. Study #2 examines more deeply *why* students might feel isolated, assuming that they do. Study #3 attempts to construct solutions to this sense of isolation and examines their effectiveness. The overall picture of student connectedness in the program is thus strengthened by these different views; Studies #2 and #3 examine a phenomenon that is more independently raised as a possibility by Study #1; Study #2 elucidates the phenomenon at a deeper level; and Study #3 emphasizes the extent to which the previous two studies' findings are actionable through the implementation of a new environment to address those trends.

Taken altogether, a multi-faceted picture of the phenomenon emerges. We hypothesized at the outset that some prior research on social isolation in online education was a product of the infancy of online social communities in general; as social media has expanded, we predicted that we might see this relationship dissipate. People are more comfortable interacting online in general now than they were 20 years ago, and it appears reasonable that this could mean students are less likely to feel isolated online now than before. While we cannot comment on whether the sense of isolation has diminished, these studies assert that it has not vanished; students desire a greater sense of community in this online educational environment. Moreover, Study #1 found that it is actually older students who feel more comfortable at present forming relationships online, further suggesting that the effect has not dissipated.

Notably, while this desire for greater community is compatible with the program's geographic distributedness, it may be incompatible with its asynchronicity. In Study #2, students largely reflected that synchronicity was important to forming social relationships, while in Study #3, environments that supplied synchronicity were specifically valued. This is what we describe as the Synchronicity Paradox: the very feature that makes this online degree program appealing is potentially incompatible with fostering a sense of student community. The reason students are drawn to the program may be incompatible with what they want out of the program.

Limitations

There are, of course, significant limitations to this work. There are many limitations inherent in research like this, like the unreliability of self-report metrics. It is also noteworthy that while two of these three studies were conducted by researchers primarily independent of the instructional staff of the courses, the implicit endorsement of the work by instructional staff may invoke a social desirability bias whereby students reflect more positively on the experience as a gesture of perceived goodwill toward the instructor.

More specific to this precise work, this research is in the context of a single program, and any trends identified here may be more specific to the program than general to online education. We are generally comfortable generalizing our findings to online programs more broadly because they are compatible with prior literature on the subject; if we had instead found that students did *not* feel isolated in this program, we would pose its design as evidence that a program *can* be designed that reduces isolation, rather than proof that isolation is no longer a problem more generally. Given that this study corroborates similar findings from other research, we feel it is reasonable to view these trends as more general.

One limitation we suspected was that student demographics might interfere with this study's conclusions. We noted that social media is more commonly accepted now, but the median age of students in this program is mid-30s; these are students who, for the most part, first entered college when access to Facebook was limited to universities. This is not an audience that grew up with social media, but rather one that adopted it as they entered adulthood. We suspected it might be the case that audiences that grew up with social media through the lower, middle, and high school years would be more comfortable online as hypothesized; however, this study actually finds that it is older audience that appear more comfortable than younger audiences, further refuting this idea. There may be a different bias introduced here, however, one in which students are specifically more or less comfortable interacting online based on their *relative* age; younger students, knowing they are less experienced than the median, may be less comfortable due to that lack of experience rather than due to inherent traits of their age.

Design Implications

While there are nuances, the most immediate and actionable takeaway of the studies above is: student isolation in online education remains a challenge (until shown otherwise) despite the prevalence of online social media, and students specifically reflect on the role of synchronicity in potentially resolving that isolation.

As posed previously, however, synchronicity presents both benefits and challenges. The program under analysis here is differentiated from traditional programs in five ways: its affordability, its admissions inclusivity, its geographic distributedness, its custom online construction, and its asynchronicity. Asynchronicity is a fundamental part of the

scalable online programs' appeal [7]. If synchronicity is a core part of forming social relationships and a sense of connectedness, then is it the case that an asynchronous online program cannot impart a sense of connectedness?

This presents a challenge for the creation of online educational programs: designers ought to find opportunities to reintroduce synchronicity without invalidating the appeal that asynchronicity brings. While apparently paradoxical, the solution to this challenge may come in the form of the same trend that asynchronicity helps deliver in the first place: scale. With sufficient scale, it may be possible to reintroduce synchronicity while retaining the flexibility of asynchronicity. Classes in this program regularly reach 600 students, and according to one student review site, demand 15 to 20 hours of work per week. Thus, while a student may have flexibility in choosing when they work on the course, it is nearly guaranteed that there will be dozens of other students working at the same time. Synchronicity may be reintroduced not by mandating that students attend class at a certain time, but rather by having "classes" emergently form around those students active at the same time.

In these studies, students' preference for a synchronous chat tool over an asynchronous forum tool echoes this dynamic; not only did it supply the desired immediacy, but asynchronous communication almost inherently conflicts with students' desire for a more transient conversational medium that synchronous mechanisms can provide. Regarding the virtual lecture halls and synchronous co-watching chat sessions, a small jump would suggest a mechanism constructed around regularly- and frequently-scheduled sessions or matchmaking mechanisms to form groups around shared schedules. This further connects with the literature, which suggests that in such activities, there must be an anchor for initial engagement [19]. Students should be given the opportunity to connect synchronously around a shared goal or activity.

While the Synchronicity Paradox suggests that the appeal of online educational programs is fundamentally in conflict with the context needed to form strong social connections, the scale that asynchronicity can deliver may afford an opportunity to reintroduce synchronous interactions. We thus suggest that designers of online education experiences should strive to build opportunities for emergent synchronicity: interactions that do not preemptively mandate attendance or interaction during a small predetermined window of time, but rather find opportunities for synchronous interaction among students' existing behaviors.

CONCLUSION AND FUTURE WORK

In this work, we have shared three studies that look at student isolation in online education. The goal of these studies is to understand whether we are losing something in the transition to online education that we never deliberately designed on campus in the first place, but that nonetheless emerged and was worth preserving.

Through these studies, we find a nuanced picture with a clear, salient takeaway. We find that students in online programs report a desire to connect and a decent ability to form connections, but that these connections may not translate into deeper social relationships. Despite reporting relatively little difficulty in forming connections and moderately positive social presence in Study #1, they more directly reported feeling isolated and alone in Studies #2 and #3. This echoes the idea that community and connectedness are functions of more than just the quantity of interaction, but also of its quality. Toward that end, these studies found that while students report little difficulty overcoming geographic distributedness as an obstacle to connectedness, synchronicity is not as easily replaced. Students report synchronous communication is a critical part of forming social connections. This is in part due to the real-time rapid exchange of ideas, but also due to the casual types of communication more compatible with synchronous interaction. Synchronous interaction removes the pressure of sharing content for a wide audience for an extended period of time, and instead focuses on intimate communication. Thus, the value of synchronous interaction comes not only from the synchronicity itself, but also from other effects that it supports.

However, research has found that these new online degrees have thrived in large part due to their asynchronous nature [7]. The types of students—usually older, more likely to be working full-time and have families—who gravitate toward these programs need learning environments that do not dictate their schedules. This, then, is the Synchronicity Paradox: the very element—asynchronicity—that makes these new programs appealing to such large, underreached [10] audiences is also incompatible with the types of interaction and community that they crave from the experience.

As a solution, however, we pose the idea of emergent synchronicity. The scale that these programs achieve creates more opportunities to build synchronous experiences around existing patterns of interaction. It is true that these students do not want to be required to attend a virtual lecture at a certain time each day; but it is also true that no matter when these students *do* decide to watch a prerecorded lecture, there are likely other students doing the same. Synchronicity can be reintroduced at scale by finding and supporting these emergent synchronous activities.

This is our recommended target for future work in this area. Some work has already been performed on providing synchronicity at scale, such as Unhangouts [11] and SyncEducate [16] for lecture co-watching, but there are many more opportunities available. Some of these may be binding but flexible, such as allowing students to select from numerous time slots in signing up for a study group or office hours session. Others may be more truly emergent, such as observing students' interactions with learning interfaces and dynamically connecting them with similar others. Through these kinds of initiatives, learning may come full circle back to synchronous experiences at scale.

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