

Explore the online interdisciplinary co-design in higher education

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During the COVID-19 pandemic, Arizona State University implemented online courses through Zoom; this research examines a graduate-level online co-design pilot course. This course brought together students from diverse interdisciplinary and multi-lingual/cultural backgrounds situated in different time zones. The authors interviewed 14 out of 28 (n=14) students in the class to explore how online co-design affects interdisciplinary student collaboration and participation. Several challenges were observed in this case. First, many students were unfamiliar with the co-design course format, leading to confusion about the overall process and their roles in the course. Second, while students were divided into teams, there were barriers identified involving cooperation between the students within their teams. Third, the team members showed a lack of comprehensive knowledge and the functions and optimal use of collaborative tools, pending their efficiency in accomplishing tasks. This paper aims to help universities and instructors develop new co-design and collaborative teaching models in the future. This study proposes retouching co-design teaching models to address the issues identified in this case, fostering seamless teamwork: 1. clarified expectations, 2. specific guidelines toward effective collaboration, promoting open and equal communication, and building reasonable leadership structure, 3. clear training on tools. Despite the challenges mentioned above, the course creates an equitable learning environment to encourage students to express themselves, and students also learn how to work effectively with others and develop empathy.

Keywords: *co-design; interdisciplinary; team collaboration; course structure*

1 Introduction

The COVID-19 pandemic has necessitated social distancing, which has now become the norm and is identified as a public good (Lewnard & Lo, 2020; Cato et al., 2020). This fact inevitably led to explosive growth in the use of digital technology (Barber, 2021). The worldwide adaptation to new work patterns has been catalyzed by the profound impact of digital technologies, providing individuals the



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opportunity to work with heightened efficiency and flexibility (Kiron et al., 2016). Arizona State University implemented several online courses during the pandemic.

In this study, the authors aim to evaluate the co-design experience within an interdisciplinary, co-design-oriented university course with twenty-eight students from diverse academic disciplines: engineering, computer science, management, and design. The students were given the autonomy to self-select into six different teams as prescribed by the co-design methodology: the Business team, the Creative team, the Media team, the Technology team, the Education team, and the Social and Civic team. The majority of the students had no prior experience with such an educational format. Thus, the university recognized the necessity to strengthen the student's understanding and training of the co-design work model to improve their communication skills and adaptability for future work situations.

Co-design exemplifies a collaborative problem-solving approach that harnesses the expertise and knowledge from diverse disciplines to address challenges in tandem. For instance, in dementia research, interdisciplinary research teams can integrate the expertise and skills from various fields to explore more effective treatments and prevention methods (Ibsen & Eriksen, 2022). By leveraging the strengths of multiple disciplines, co-design allows cohesive research plans and goals, resulting in collective intelligence from teams.

This research aims to explore how universities and instructors can foster collaboration among students in co-design courses, enabling them to acquire and proficiently apply co-design skills. The authors acknowledge that online co-design can present some challenges, such as limited face-to-face interaction and the difficulty of maintaining a sense of teamwork. The study specifically focuses on a group of students from diverse interdisciplinary backgrounds, with the objective of deepening the understanding of co-design pedagogy in this context. By interviewing students and their perspectives on working remotely on a co-design project, the authors hope to understand how remote work impacts collaboration and draw insights and recommendations on how students can proactively employ collaboration techniques unique to the online environment. The primary target audience of the paper includes universities seeking to develop innovative teaching curricula and educators interested in exploring novel approaches to instruction.

2 Literature review

2.1 Co-design learning process

Participatory design is a collaborative approach to designing products, services, and systems that aim to incorporate the diverse perspectives and expertise of stakeholders into the design process (DiSalvo et al., 2013). Both design researchers and practitioners are increasingly interested in co-design methods (Pedersen, 2016). Unlike the traditional teacher lecture-based classroom, the center of the online learning classroom is the student, with the teacher adopting a guiding role. Effective guidance entails timely and constructive feedback to the students while also providing care and help to the students as a social supporter (Eom et al., 2006; Hung & Chou, 2015). Nevertheless, technological challenges may hinder collaboration, although teachers can provide technical support and collaborative activity guidelines for students to improve efficiency and student performance (Capdeferro & Romero, 2012, Gómez-Rey et al., 2018). However, not every interaction produces

cumulatively effective and active outcomes. Purposeful student-to-student and student-to-instructor dialogue can influence the outcome of learning (Abrami et al., 2011).

Co-design can be challenging because of the diversity of participants. Divergent understandings, values, and concerns may lead to conflicts among students (Cossham & Irvine, 2021). Online collaborative work presents additional obstacles, such as varying levels of responsibility and commitment among students, resulting in imbalances in workload due to disparate skill levels. Some students may show lower engagement in the course or have difficulty with interpersonal communication (Chang & Kang, 2016; Brindley et al., 2009). Some students have difficulty working with others, possibly because of uneven workloads, lack of discipline and feedback (Warr & West, 2020).

Effective communication is essential in interdisciplinary collaboration due to participants' diverse backgrounds. Using simple explanatory language ensures mutual understanding among all members involved. As listeners, they should also actively listen and keep an open mind to summarise what is understood and ensure the discussion output is valuable (Dahm et al., 2019). The more perceived voice people have, the more advice they can share with their colleagues, and thus more interdisciplinary collaboration can be built (Cosley et al., 2017). However, managing a multitude of opinions can be challenging, necessitating democratic leadership and clear direction for effective decision-making. (Nancarrow, 2013). Furthermore, cognitive quality and a clear mission for the participants, positive emotions of feeling respected and trusted, and joyful and effective interactions contribute to the success of the interdisciplinary collaboration (Mansilla et al., 2016).

Learning skills from other disciplines can facilitate interdisciplinary collaboration (e.g., STEAM, Science, Technology, Engineering, Arts, and Mathematics). For instance, technology majors can learn business and design skills (Stenard, 2021). Recognizing the strengths and weaknesses of one's discipline fosters empathy and understanding of the thinking of other fields (Gardiner, 2020). Design students also could play an essential role in interdisciplinary collaboration, also known as the facilitator, where their knowledge of the entire process is needed in order to guide it in an orderly fashion. A mature designer should be good at the creative process and function as an expert in the team (Sanders & Stappers, 2008).

2.2 Student learning outcome from co-design education

Co-design in education, characterized by collaborative efforts between students and teachers to design and deliver course content, is believed to bring innovations in pedagogy. This approach benefits both students and teachers by promoting interdisciplinary collaboration, developing critical thinking and self-reflection, and fostering student leadership skills (Blau & Shamir-Inbal, 2018). Through interdisciplinary collaboration, students enhance their ability to communicate with peers from diverse disciplines, listen patiently and explain terminology, acquire a deeper understanding of their own discipline while exploring other fields, as well as skills that will prepare them for future careers in diverse industries (Warr & West, 2020). In addition, co-design empowers teachers to adapt and evolve their teaching methods, offering fresh perspectives and opportunities for growth (Penuel et al., 2007).

The advantage of co-design courses over traditional courses is to engage students as active participants rather than passive learners. Through meaningful discussions with peers, students acquire knowledge in a collaborative process, resulting in improved learning outcomes (Brindley et al.,

2009). This positive effect will be further enhanced by the involvement of online learning. The online collaborative design approach also helps break down power imbalances between participants and establish an equitable learning environment conducive to students' learning enthusiasm (Kennedy, 2021). Virtual environments are helpful for student skill development, as co-creation and using digital tools in a digital environment enhance students' learning autonomy (Woods & Homer, 2022). While co-design education may not necessarily improve the creativity of design students, it empowers their ability to integrate their thinking and act as facilitators (Lee et al., 2019).

2.3 The collaboration tools

Collaboration tools are essential for effective teamwork. These include: supporting equal decision-making, exploring solutions, and understanding the design process (Heiss & Kokshagina 2021). Several collaborative tools are employed for communication and knowledge sharing during online student collaboration. The text chat tool for real-time communication weakens the implication of identity and empowers participants equally (Blau & Barak, 2012). Diagram-based visual thinking tools enhance group knowledge sharing, boosting collaboration efficiency and providing a clearer perception of learning activities for participants (Cai & Gu, 2019). Implementing group reporting allows students to make positive changes in online collaboration, increasing group awareness and improving the quality of collaboration (Crisanto, 2018). For teachers, online editing tools such as Google Docs enable management and monitoring of students' project progress (Kai-Wai Chu & Kennedy, 2011). When collaboration tools are appropriately utilized within the collaborative process, they contribute to improved teamwork. However, other factors should be considered, such as team size and cultural differences in the team. A combination of factors can help teams collaborate more effectively.

Visual online collaboration tools can be an aid for students, but it is important to consider that sometimes students may become overly focused on the tools and ignore the communication content. In such cases, using simpler and more universally accessible tools may be preferable to visualization tools (Lee et al., 2019). However, Jin (2016) stated that visual online collaboration tools can increase student engagement and a sense of community. Visual feedback aids participants in monitoring their online learning and allows for comparative observation of others' engagement. The storyboard tool can demonstrate the collective imagination of participants through a four-step structure: Wonder, Find, Think, and Create (Wong et al., 2021). Use a customer journey map to understand the emotional ups and downs of interactions (Kolko, 2015). Each tool comes with its own set of advantages and disadvantages, making it crucial to select the most appropriate tool based on specific scenarios. Visualization tools and storyboards are commonly used in online collaboration; however, acquiring the necessary skills to effectively use these tools may be imperative to help our students develop better memory, understanding, and critical thinking skills (Santiago, 2011).

3 Description of the study

3.1 Objectives and outcomes of the study

The online co-design format was adopted as the educational method by Arizona State University during the pandemic class was enrolling 28 students from diverse disciplines, all pursuing at least master's degrees. In this course, students were introduced to the principal frameworks, infrastructure, and technologies used in the co-design process of citizen-centered smart cities, focusing on people with dementia. As part of their coursework, students were required to submit an Institutional Review

Board (IRB), post blogs, and interview stakeholders. Students improved their skills in identifying key stakeholders, gathering evidence through interviews, creating needs identification and requirements analysis documents, and assessing the consequences and feasibility of proposals in the real world. The focus of the course was on practice facilitating the co-design process to generate innovative solutions for significant social impact.

3.2 Detail of course outline

The Co-design process consists of five parts: Co-Initiate, Co-Discover and Co-Inspire, Co-Define, Co-Develop, and Co-Deliver (Figure 1). The first task was completing an Institutional Review Board Social Behavioral Application. Then there were class activities to gather people together. Next, three workshops were held in class: 1. Co-Initiate and Co-Discover; 2. Co-Inspire and Co-Define; 3. Co-Develop and Co-Deliver.



Figure 1. Co-design process

Based on the needs of the co-design process, the students were divided into six teams: the Technology team, the Media team, the Social and Civic team, the Creative team, the Education team, and the Business team. Each student had the opportunity to choose two roles: a primary role, representing their main area of contribution, and a secondary role, indicating the role they wished to learn more about. The Technology team was responsible for development, integration, and implementation. The Media team, on the other hand, was responsible for communications, social media, journalism, and

visual engagement. The Social and Civic team was dedicated to addressing social justice issues, environmental laws, regulations, human rights, and equity. The Creative team focused on problem solvers, sensemakers, ideators, proof of concept, and solutions advisors. The Education team took charge of facilitating, teaching, public engagement, support, and project management. The Business team mainly contributed to strategy, feasibility experts, and competitive intelligence.

3.3 The Workshops

The primary purpose of the first workshop was to explore the space of potential stakeholders and their relationships to pre-register assumptions about the domain before co-exploration with stakeholders directly. The focus of this workshop was to emphasize the importance of inclusivity and engagement with all stakeholders to foster the development of a comprehensive theory of change or product that would enhance the lives of dementia patients. Students collaborated to research, make system sketches, interview stakeholders, collect data, and analyze the interview takeaways. They also used different tools such as value proposition and persona creation to understand stakeholders and their pain points better. The resulting profiles were used for the Journey map to understand stakeholders' everyday challenges and lives. Digital tools like Jamboards were used to facilitate collaboration. The activities in the workshop were designed to help students learn how to interview stakeholders.

During the second workshop, students centered their efforts on integrating and synthesizing information to define a problem related to dementia and develop a prototype for testing. The students used Wonder.com as a conversation tool and participated in a four-round activity. They shared their interview experiences and used the information to create a sketch of a future system, brainstorm design principles, and voted on the top 6 principles: accessibility, affordability, and scalability; easy-to-understand explanations; solutions with necessary education; plan for future change; focus on compassion and joy; and a broad audience from many demographics. The students then broke out into different groups to discuss the "Action Narrative," a short, specific narrative about how the system works. This exercise effectively grounded the action items in practical contexts, enhancing the student's understanding and ability to translate their ideas into real-world scenarios.

In the third workshop, students collaborated to reach a consensus on the problem and proposed potential solutions. At the end of this class, students had a pitch for a deliverable coordinator, and students had the opportunity to elaborate on their involvement. After discussion, students collectively decided to carry out three projects as the final solution: 1. RememberMe - a Facial Recognition Application for friends and family; 2. Sound and Light Therapy; 3. V2I and V2V Framework. In the Post-co-deliver stage, students finalized their class outcomes and contemplated future directions for this project. Students composed an action narrative statement on cards in the Jamboard platform (Figure 2). Imagining an extended timeline of five years, they meticulously organized the Action Narrative Cards into a coherent and realistic timeline for their projects' implementation and development over the envisioned period.

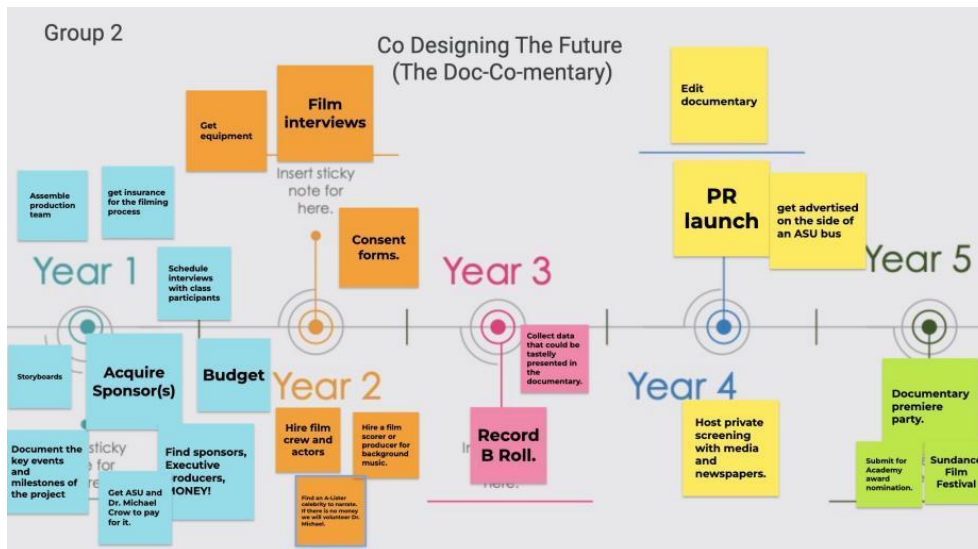


Figure 2. Five years milestones

4 Methods

The primary focus of this study was not to investigate how co-design was specifically used to address concerns concerning people with dementia, but rather how students were co-designing in the classroom. This study used qualitative research methods, such as interviews with student participants, to gather data and insights about the co-design process. Two authors each interviewed one team member, and another two authors interviewed two teams with fewer members. Each of the three authors was responsible for interviewing members of one team, and another author was responsible for members of the two smaller teams. The authors developed a set of questions (Appendix A) that each interviewee answered verbally over a recorded Zoom meeting. The questions were designed to probe the student's experience a) in a co-design environment and b) collaborating in a virtual environment. The interviewers were trained to facilitate the questioning using a design thinking approach. A design thinking approach allows people to look at problems more systematically and empathetically (Owen, 2007). All participants received the same questions and were allotted the same time to respond. The study sought to shed light on the dynamics and effectiveness of co-design/collaborative activities among students within the virtual classroom environment.

4.1 Participants

This study involved conducting interviews with students who were enrolled in a class held at Arizona State University. The class was structured with self-organized teams, and a representative sample of these teams was selected for the interviews. Out of a total of 28 students, 14 (50%) participated in the interview, representing various teams, including Education, Creative, Media, Technology, and Business. Four of the authors of this paper are also students in this co-design course. Three are on the creative team, and one is on the education team. The four authors also interviewed each other. Their interviews of each other were conducted after the other students were interviewed.

4.2 Data collection and analysis

In the process of conducting the Zoom interview, the authors received permission from the interviewees to record the Zoom. After the recording, the video is stored in the cloud and can be

downloaded as an automatically transcribed text file. Based on students' interviews, the authors used several codes to categorize all the interview responses for the qualitative analysis. The authors used Google Sheets to categorize all the interviews because Google Sheets (an online collaborative work tool). Each author first coded the data based on the students' interviews, and when finished with all the data summarized, the authors found that the content of the data coded for each interview did not differ much. Some codes with similar meanings could be merged, and codes with ambiguities were discussed on whether to eliminate them.

Finally, the authors identified the final 15 codes. These codes matched all the data and included topics, such as: 1. Understanding the co-design process. 2. The role of facilitator and participants. 3. Students learning outcomes. 4. Clear goal. 5. Collaboration conflict. 6. Challenges of collaboration. 7. Internal team communication. 8. Between team communication. 9. The use of tools among groups. 10. Confusion about the communication tools. 11. Empathy. 12. Diversity. 13. Culture shock from disciplines and personalities. 14. Self-organizing ability. 15. Team leadership.

After the authors had critically examined all the codes, they grouped them into three main themes: structure of the course; collaboration with internal teams and between teams; workshop and digital tools. The authors were able to identify critical areas of focus, make connections between different pieces of data, and draw conclusions or make recommendations based on their findings.

Table 1.

Themes	Codes
Structure of the course	1. Understanding the co-design process. 2. The role of facilitator and participants. 3. Students learning outcomes. 4. Clear goal.
Collaboration with internal teams and between teams	5. Collaboration conflict. 6. Challenges of collaboration. 7. Internal team communication. 8. Between team communication. 12. Diversity. 14. Self-organizing ability. 15. Team leadership.
Workshop and digital tools	9. The use of tools among groups. 10. Confusion about the communication tools. 11. Empathy. 13. Culture shock from disciplines and personalities.

5 Results

5.1 Structure of the course

The course was designed to prioritize research conducted through a Co-Design process, where students were allocated different roles and responsibilities. The use of groups and designated leaders within each workshop was instrumental in ensuring effective research (Figure 3). However, 9 out of 14 students from the Media team, Education team, and Creative team reported encountering challenges with the course setup. They expressed concerns about the lack of clear explanations regarding the different structures employed in the course.

“But I didn’t realize exactly what the outcome of the class was, so when it came to creating and facilitating the workshops, it was off and ambiguous how we could best facilitate the outcomes for the class based on the outcomes it should be. But as the class went on, I realized

like the whole point of the class is to practice facilitating the workshop, understand the co-design process, and output those blog posts; and it wasn't a lot of items; it was just initially, or it's just ambiguous to its ongoing way"

Student from Technology team

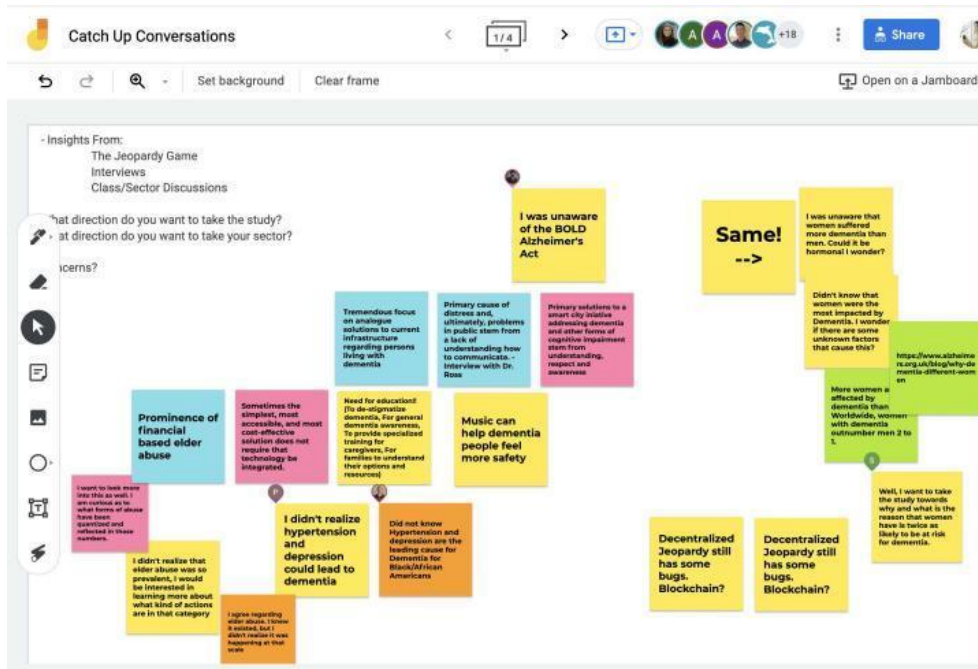


Figure 3. The Jamboard

Four interviewees expressed confusion regarding the number of blog posts they were required to write and the purpose of these blogs. Additionally, the interviewees mentioned that precise delivery dates for the tasks were missing, and the content of the blogs was disconnected. It also appears that one student made inflammatory comments on another student's blog post, which was then deleted. The lack of experience reviewing and managing the system also posed challenges for some students.

In the context of online co-design learning, students who are new to the process may encounter difficulties in grasping their role and the final goal of the course. The students were asked to wear two hats, one of which was facilitating the co-design experience. Then the second hat they wore was as a participant in the co-design experience. The reason for wearing multi-hats was that the class did not have participants to facilitate.

“It is difficult to understand what the end goal was and difficult to understand what my part in the process should be, and that took quite a lot of time and work as well.”

Student from Media team

This course aims to simulate a natural, unstructured environment, providing students with the freedom to think and take initiative. However, the lack of defined structure and guidance initially led to confusion and inefficiencies for some students. To address this issue, it is suggested to establish a transparent system or structure at the beginning of the course. This would assist students in

understanding the project's process and objectives, providing clarity on their roles within the course. Additionally, students would benefit from having a framework to define their goals and a means to seek feedback and guidance from the instructor. While the course aims to teach valuable skills through the exploration process, it is essential to strike a balance between the freedom for students to think independently and the provision of clear structure and guidance.

5.2 Collaboration with internal teams and between teams

Collaborating can be challenging when some students are unwilling to compromise and hold firm beliefs that their ideas are superior. Effective communication is vital in facilitating collaboration, but coordinating meetings with large cross-teams can be difficult, especially in a university setting where schedules may vary.

The Education team consisted of about 5-6 students, some previously on the technology team. The team demonstrated commendable internal and external communication; most work was completed early. By working together, the team members developed a sense of trust and cohesion, enabling them to function harmoniously. The team leader assigned tasks based on team members' specializations and communicated frequently with students from other teams to stay informed about progress. Collaboration was especially strong between the Education team and the Media team, as they collaborated closely on blog editing. Although there was less interaction with the Business, Creative, and Technology Teams, the Education team leader proactively communicated with the outreach staff of those teams to stay abreast of their progress and ensure effective collaboration across the board.

The Media team started with one student, but later it expanded to include a member from the Creative team and another from the Technology team, forming a three-student team. The Media team faced challenges at the outset because the class was given the flexibility to establish the class goal, but once the objectives were settled, they made steady progress. Each team member then had clear responsibilities: one was in charge of tracking the blog and headcount, another handled the website and informational image changes, and the third person organized the reference system. The Media team often contacted other teams to collaborate but sometimes felt isolated unless they made a deliberate effort to connect. Their interaction with the technology team was limited, but they received valuable advice from the Business team regarding the feasibility of the conceptual product and marketing strategy for dementia patients. On the other hand, The Creative team displayed strong participation in internal meetings but lacked clear leadership and structure within the team. The absence of established rules or guidelines, as well as a lack of direction and planning responsibilities, contribute to the team's challenge. Additionally, communication and understanding between the Creative team and other teams were insufficient, with some teams being unaware of the Creative team's specific role in the co-design process.

"I honestly had no idea what the creative team did. Other than a member of the creative team that was helping me create a presentation, they put their creative look and spin on the presentation, and that was a great add value, but as a team contributing to the Co-design experience or as a participant in the co-design experience, I have no idea what they did."

Student from Education team

The Technology team had the most members and took the lead in driving the overall project. However, the team members had individual ideas regarding the project, which made it challenging to collaborate. There was only one member from the Social and Civic team, whose background provided a valuable perspective for analyzing the product's feasibility. On the other hand, the Business team members felt there were limited opportunities to collaborate and communicate with the other teams. Aside from workshops conducted in class, there were few chances for meaningful interaction and communication between the teams.

5.3 Workshop and digital tool

In this online collaborative course, students utilized several digital tools such as Zoom for group meetings and stakeholder interviews, Slack for instant communication with classmates, and Google Drive for shared and editable project management files. A student from the Creative team expressed a preference for email over Slack, citing accessibility and frequency of use as reasons. However, another student from the Tech team believed Slack is more likely to lead to casual conversations than email. Additionally, three students mentioned experiencing difficulty with Google Drive, specifically in locating specific files due to a lack of clear document organization. The workshops were an excellent opportunity for different teams to do activities together, led by a leader who organized the training for each activity. Online collaboration tools like Jamboard allowed for effective communication and collaboration, and the interdisciplinary perspective gained from the activities was valuable. However, there were issues with organization and coordination, resulting in a lack of continuity and repetition in some workshops. Further, the reflection time was limited, and workshops at the end of the semester were more valuable than those at the beginning. Overall, while some workshops were valuable, others were not as helpful.

"I think a lot of the workshops at the beginning of the semester were less helpful than the workshops towards the end. Once we actually started it being solutions and, you know, discussing different possibilities of where to go with the project, I think that time was better spent, or more productive towards end goals, than some of the earlier workshops."

Student from Media team

Many students learned how to be more empathetic and open-minded during the course. For example, a student from the Education team did not quite understand what the Business team was trying to do and felt that they just wanted a good and profitable product. But through the workshop, they slowly understood their point of view that a product needs a business model to maintain and operate; otherwise, it is challenging to design a product that will be successful in the market. Another student from the Technology team felt that by interviewing different stakeholders, they learned how to overcome bias and become more attuned to the needs of others.

"I think I learned to be a little more empathetic and open-minded to others from the workshop setting. Everyone does have something valuable to contribute."

Student from Education team

6 Discussion

The study explores the learning experience in a new teaching approach—an online student co-design course under the influence of the pandemic. In the literature review, authors found factors that

influence learning outcomes: effective collaboration among students (Mansilla et al., 2016), the realization of self-efficacy (Blau & Shamir-Inbal, 2018), and proper use of collaborative tools (Kai-Wai Chu & Kennedy, 2011) all influenced course outcomes. The authors' investigations found that these factors did have an impact on online co-design courses. Also, a clear course structure is essential for students taking a co-design course for the first time. Design students can play a professional role in the co-design process, bringing unique professional insight and creativity to the team. Sanders & Stappers (2008) describe that designers should specialize in the creative process to become experts in the team; however, designers did not play their professional role in this co-design learning process.

6.1 Improve collaboration

Collaboration between students from different disciplines can be challenging due to different working patterns and areas of expertise. Students need to practice empathy and overcome bias by listening to others' needs, tolerating different ideas, and providing space for others to use their skills. Effective communication is also crucial and may require continuous translation of meanings (Mejia, 2020). It is important to remember that the workload of co-design can be substantial, and students should be flexible and willing to iterate to find the best solution.

The Education team received unanimous praise for its effective transdisciplinary collaboration, attributed to its democratic leadership and clear direction (Nancarrow 2013). The team's leader was skilled in organizing tasks and meetings efficiently and setting clear deadlines for the team members. Furthermore, the team had a strong rapport and empathy among its members, which motivated them to work towards completing their tasks. Kennedy (2021) stated that online co-design helps break down the power imbalance between participants. The students feel they are participating in the project to the best of their ability and are not uncomfortable with the leader's task assignments. Perhaps this open and transparent decision-making process would allow students to be more able to express their basic ideas and accept other people's decisions. To improve teamwork skills and adopt an open leadership style, the team can focus on collaboration and innovation to achieve organizational goals (koÇak, 2019). One way to do this is by using a lateral leadership approach that disregards hierarchy. Before each workshop, the activity leader can send a newsletter to all students to inform them about the workshop's purpose and expected outcome, allowing for better collaboration efficiency. Technology is helpful for co-design; online collaborative tools can help students improve collaboration efficiency and visual thinking (Cai & Gu, 2019). However, it is not the key to success; technology can be used to enhance online co-design, but it should not be relied on as the sole solution. It is important to use communication tools familiar to all team members to avoid insufficient communication.

6.2 Expectations for the class

In online co-teaching, the role of the teacher has shifted to providing technical support and guidelines for student collaborative activities, which can make the process more efficient (Gómez-Rey et al., 2018). In the class, each student had to play both roles: facilitator and participant. This increased the difficulty of collaboration and the lack of clarity in defining roles. Therefore, it was better to separate the two roles. Soft skills and training sessions can also help students quickly find their place in the collaboration. Additionally, students should not be expected to be expert participants, but should be provided with a collaborative design experience to learn how to facilitate and generate good ideas. The role of the facilitator throughout the process should be to guide students, clarify what is being done, and resolve conflicts. However, most facilitators were not capable of doing this. They had not

received any training, and many were acting as facilitators for the first time. The students in the course express a desire for the instructor to take on more responsibility for clearly outlining the objectives and structure of the course and to provide more direct answers and guidance when questions or confusion arise. They also suggest that setting additional expectations for student initiative and organization at the beginning of the course would have helped them feel less overwhelmed and work together more effectively earlier on. Additionally, the students suggest introducing explicit cultural norms at the beginning could have prevented some conflicts.

Some teams were too small, with only one student, and some were too large, with eight students. An unbalanced student workload makes working with others difficult (Warr & West, 2020). It is recommended that in a learning environment, the instructor can play a role in balancing the number of team members rather than allowing for random selection to avoid these issues. Additionally, assigning clear roles and responsibilities to each team member can help prevent confusion and ensure everyone's contributions are utilized effectively.

In summary, the unconventional course did not have systematic instruction or reading materials, leaving it up to students to do their research. This makes it necessary to evaluate students fairly and ensure that they manage their time effectively; using a time management software like Clockify was suggested. Additionally, having specific deadlines for each project within the group could have helped students complete their final product models. However, the students could not complete the models due to time constraints (i.e. workshops running over time, pushing work further out).

6.3 Efficacy

Students are mostly passively educated in an academic environment. The advantage of co-design courses is that students actively acquire knowledge through discussions with their peers (Brindly et al., 2009). Some students mentioned that their personalities are not used to expressing their views in large groups, but if they do not, no one will hear their opinions. Online collaboration creates an equitable learning environment (Kennedy, 2021), so this is a good learning experience for students to express their points of view. There may be some initial chaos and difficulties adjusting to this type of collaboration. Still, it can be a valuable experience for students to learn how to navigate and solve problems in a team setting. However, it's important to note that some students may not be accustomed to this type of collaboration and may require additional support or guidance.

Interdisciplinary collaboration can be a valuable learning experience for individuals. People recognize the strengths and weaknesses of their disciplines and develop empathy and understanding of the thinking of other disciplines (Gardiner, 2020). It is essential to clearly define roles and responsibilities within the team and encourage open communication to ensure everyone is on task and comfortable stepping out of their comfort zone.

The workshop encourages all participants to take on leadership roles and develop their skills. However, some students may lack motivation or struggle with communication. To overcome these challenges, team members should encourage them to share their ideas, help group members learn, encourage the accomplishment of team goals, and emphasize others (Abrami et al., 2011). Besides, students should work on overcoming their fear of taking on leadership roles, which can turn pressure into motivation.

7 Conclusions and future research

The contribution of this study is to provide a new way of thinking for developing new co-design teaching models in the future. The feedback from this course can help similar courses be designed more effectively in practice. Co-design is an efficient interdisciplinary collaborative approach that can help solve the problems of diseases such as dementia. It can integrate the expertise and skills of different disciplines into a collaborative and collectively intelligent team, thus improving the quality and efficiency of research results and providing better solutions to humanity's complex problems.

As a new course, online co-design courses have their natural advantages; they can create a more equitable learning environment for students. Most of the students learned the natural benefits of co-design from this experience. They learned how to be a good facilitator, effectively work with others, and express their ideas positively. The consensus, however, was that it could have been better. There are three suggestions for future co-design course enhancements. First, establish a complete framework at the beginning of the course to lay a clear foundation for communication. For example, set a cultural norm to avoid unnecessary conflicts during the collaboration process. Second, avoid giving students two hats simultaneously as participants and facilitators; do not set multiple roles for students so they can focus on getting one position right. Third, establish a trusting environment of collaborative communication. Use open leadership and encourage every student to participate in expressing their point of view by using alternative engagement tools. Learn to empathize and trust others, be tolerant of others' ideas, maintain a patient attitude, and provide space for others to use their skills.

This class is primarily understood from the student's perspective. The limitation of this paper is that the authors are also involved in the entire design process as students of this course, so some points of view may lack objectivity. The authors did not get an interview with the instructor for various reasons, so they do not know what they feel about the class and what they consider about improving it. They hope to understand the course from the instructor's perspective in the future to avoid systematic bias. While most students report that they have learned some skills in the course, it is best to systematically assess whether the co-design course has enabled students to improve their skills.

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Appendix

The Student Interview Protocol

Goal: Draft interview questions that help the reader to understand the user's experience in the co-design collaboration process via virtual format

Questions

1. Tell me about your experience in a co-design process.
 - How do you do your work? Walk me through a typical day; step by step.
 - Who do you interact with? And what is that exchange like?
 - Do you think those online tool used in class help us facilitate better workshop?
2. What did you like? What could have been improved? What is the most challenging part of your work?
 - What do you think you learned from this experience?
 - What do you think the role of our instructor was? Did the instructor help with the communication?
 - What did you think about the workshop setting?
 - What did you think about the structure of the experience?
3. What did you think about the communication between your team members and between teams?
 - Do you feel that other groups have accomplished their tasks?
 - Were there any conflicts in the process of the communication, how did it happen? And how did it get solved?
 - Do you have any suggestions that can improve the communication in your team and between different teams?
4. How does technology play a role in your day-to-day? If not, could it?
5. If someone else wanted to facilitate a co-design experience, what are the top things that you would suggest to them?
 - What suggestions would you give if your friend is going to take this class?