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การจัดการเรียนการสอนทางไกลเพื่อทักษะการร่วมมือและทักษะการแก้ไขปัญหาอย่างสร้างสรรค์ในสาขาวิชาวิทยาศาสตร์เมืองในระดับบัณฑิตศึกษา

Remote Teaching for Collaboration and Creative Problem-Solving Skills in Undergraduate Urban Science: A Case Study

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บทคัดย่อ

ศาสตร์การสอนสาขาวิชาเมืองศึกษา (Urban Studies) แบบเดิมอาศัยการเรียนรู้ผ่านประสบการณ์ เช่น การตรวจเยี่ยมสถานปฏิบัติงาน การสำรวจภาคพื้นดิน การมีส่วนร่วมในชุมชน ซึ่งกำหนดให้มีการเรียนรู้ในสถานที่จริงและมีปฏิสัมพันธ์ทางสังคม การระบาดของโรคโควิด 19 เปลี่ยนแปลงการเรียนการสอนในระดับอุดมศึกษาทั่วโลก รวมทั้งสาขาวิชาเมืองศึกษาในระดับปริญญาบัณฑิตด้วย มาตรการด้านสาธารณสุขส่งผลต่อการเปลี่ยนแปลงนี้อย่างหลีกเลี่ยงไม่ได้ ในขณะเดียวกันก็สร้างโอกาสพิเศษให้ทดลองแนวคิดการเรียนรู้ใหม่ ๆ จากการเพิ่มขยายของเทคโนโลยีสารสนเทศ งานวิจัยฉบับนี้นำเสนอพฤติกรรมและปฏิกิริยาตอบสนองต่อการปรับเปลี่ยนการเรียนรู้ท่ามกลางสถานการณ์การระบาดของโรงโควิด 19 หน่วยการเรียนรู้ 2 สัปดาห์ ท้าทายการจัดการเรียนรู้ของครูในการส่งเสริมทักษะการร่วมมือรวมพลังและการแก้ไขปัญหาอย่างสร้างสรรค์ของนักเรียน ผลการศึกษานำเสนอวิธีการที่ครู (ก) ทบทวนแนวคิดเกี่ยวกับศาสตร์การสอนของตนเอง (ข) ออกแบบหลักสูตรรายวิชาสำหรับการจัดการเรียนการสอนทางไกล เพื่อส่งเสริมการร่วมมือรวมพลังและการแก้ไขปัญหาอย่างสร้างสรรค์โดยเฉพาะ และ (ค) จัดการเรียนรู้ตามที่ออกแบบ ผู้วิจัยนำเสนอข้อสรุปพร้อมข้อเสนอแนะสำหรับการฝึกอบรมเพื่อพัฒนาการแก้ไขปัญหาอย่างสร้างสรรค์และกลยุทธ์การสอนในอนาคตสำหรับครูในสภาพแวดล้อมการเรียนรู้แบบปกติใหม่

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Abstract

Conventional urban studies pedagogy approaches rely on highly situated experience through site visits, ground surveys, and neighborhood engagement that require learning on the scene with social interaction. The COVID-19 pandemic has disrupted higher education worldwide, with undergraduate urban studies education being no exception. Such public health protocols have caused unfortunate disruptions but have also created unique opportunities for experimenting with new learning approaches augmented by information technology. This paper describes actions and reactions towards learning adaptation throughout the COVID-19 pandemic. This two-week learning unit challenged instructors' facilitation of students' collaborative and creative problem-solving skills. The findings reveal how we (a) re-examined our pedagogical approaches, (b) designed the course for purposes of remote teaching, particularly for facilitating collaborative and creative problem-solving skills, and (c) implemented/taught the course. Finally, the authors conclude with suggestions for future problem-solving training and teaching strategies for instructors in 'new normal' learning environments.

Keywords: Remote Teaching, Collaboration, Creative Problem-Solving, Urban Science

1. Introduction

The COVID-19 pandemic has disrupted higher education worldwide, with undergraduate urban studies education being no exception. Curriculum and in-class teaching have adapted to various pandemic policies, being either remote or hybrid, depending on the situation (Bozkurt & Sharma, 2020). Such public health protocols have caused unfortunate disruptions but have also created unique opportunities for experimenting with new learning approaches augmented by information technology (Hodges et al., 2020). These experiences trigger questions about teaching and learning in the 'new normal'.

This paper describes actions and reactions towards learning adaptation throughout the COVID-19 pandemic. Halfway through the Spring 2020 semester, the Massachusetts Institute of Technology (MIT, or 'Institute'), in which both authors had taught at the time, announced a complete shutdown of campus and a pivot to emergency teaching by way of fully remote teaching. This policy had lasted throughout the spring semester and the fall 2020 semester. During the fall semester, the second author led instruction for a fully remote first-year undergraduate challenge-based course which included a two-week section involving an urban studies challenge, co-taught with the first author. The course, together with its urban studies section, has continued evolving from spring 2021 through to fall 2021, and its fall 2022 iteration (fourth in number) is currently under planning.

In this paper, we discuss (a) how we designed and implemented the first, remote iteration of the course, (b) how course design and pedagogy evolved with the changing modalities of teaching and learning imposed by institutional response to the COVID-19 pandemic, (c) our successes and areas for

improvement, (d) our suggestions for instructors in the 'new normal', based on our experiences, and (e) our conclusion based on our experiences with teaching during the pandemic.

In this work, we raise critical questions for urban studies education, such as what methods or technology should be integrated into regular teaching in the 'new normal', and how urban studies instructors can accommodate the new situation where some students are on-campus while others are remote.

2. Theoretical Background

2.1. Creative Problem-Solving

As the world becomes more volatile, uncertain, ambiguous, and complex (Scott, 2015) and with automation expected to spread rapidly to more sectors of the economy (Nedelkoska & Quintini, 2018) the need for more creative problem-solving skills in the workforce has come to the fore. The need for more creative problem-solvers in the US job market has been demonstrated in general (World Econ Forum, 2016) and in science, technology, engineering, and mathematics (STEM) professions in particular (ABET, 2022)

On their part, educational organizations have stressed the importance of teaching creative problem-solving in science and engineering undergraduate education (ABET, 2022; National Research Council, 2012). The most difficult engineering problems have multiple potential solutions and a non-prescribed path to a solution. Solving these problems, which can broadly be called design problems, involves the creation of artifacts which requires creativity (Jonassen, 2000).

While no consensus exists regarding the standard definition of creativity, the two components of creativity which are most mentioned are novelty and usefulness. Novelty has been described by various terms, such as an idea being rare within a particular group (Runco & Jaeger, 2012) "uncommon" (p.478) (Barron, 1955), or unique (Berg, 2014), while usefulness has been defined as utility, "adaptive to reality" (p. 479) (Barron, 1955), effectiveness, or valuability (Runco & Jaeger, 2012; Berg, 2014).

The creative problem-solving process (Hélie & Sun, 2010) is characterized by a long period of incubation, where the problem is ruminated over, mostly non-consciously. This tends to be the longest period within the creative problem-solving process. What (hopefully) follows the incubation stage is illumination – the 'eureka' moment where the perception of the problem turns from novel to familiar and an idea is generated for solving it.

2.2. Remote Teaching in Undergraduate Urban Studies

2.2.1. Education Transformation in Undergraduate Urban Studies

Undergraduate education in urban studies focuses on a holistic understanding of cities and comprehensive skill sets involving research, design, policymaking, community engagement,

and technology. Since most urban studies programs are based in architecture schools, conventional studio teaching focuses on the physical and visual aspects of the city through a 'learning-by-doing' model (Arefi & Triantafillou, 2005). Architects, city planners, geographers, and sociologists influence the conventional urban studies' pedagogical approaches. For example, Jane Jacobs' theory has emphasized the importance of a bottom-up planning process with community engagement and public participation. William Whyte has introduced the 'people watching' approach for objectively observing and documenting the usage of public space and people's interactions. Jan Gehl further set up a set of on-site qualitative research methods for analysing the physical characteristics of the urban built environment and people's behavior. Thus, these approaches usually rely on highly situated experience through site visits, ground surveys, and neighborhood engagement that require learning on the scene with social interaction.

In the recent two decades, the rapid technological advancement and massive deployment of information systems internet of things, big data, and cloud computing have created vast data sets for studying cities. The digitization of cities has transformed the theory, practice, and pedagogy of urban studies (Kontokosta, 2021). Such transformation provides new tools and methods for studying cities and brings new research questions and professional fields emphasizing the concept of 'digital cities' (Ishida & Isbister, 2000). Urban Science is a transdisciplinary field investigating urban systems' complex processes and dynamic behaviors (Lobo et al., 2020). It relies on combined approaches from natural science, social studies, engineering, and computational sciences, fusing various theories and methods from urban planning, architecture, civil engineering, geography, sociology, informatics, and other relevant disciplines. With a strong interest in real-world problem-solving, urban science education emphasizes specific urban context and problem setting with practical training and hands-on participation.

Distinctive from the conventional urban studies, urban science students often use cities as their laboratory to observe, monitor, quantify, analyze, and instrument various environmental-social-technical factors in cities, and data as an intermediate layer to connect various components across urban systems. Urban science is segmented by multiple disciplines as an emerging transdisciplinary field, requiring domain knowledge integration and multi-party collaboration (Acuto et al., 2018). Thus, it requires a high degree of collaborative and creative problem-solving skills, which are acknowledged as a vital capacity by leading employers and educational bodies (World Economic Forum, 2016; Jang, 2016; Ananiadou & Magdalean, 2009).

2.2.2. Disruptions to Undergraduate Education During the COVID-19 Pandemic

Response to the COVID-19 pandemic, which became global in March 2020, has caused the largest disruption to higher education in world history, with more than 90% of the world's student population estimated to have been affected (Pokhrel & Chhetri, 2021). Comprehensive, globe-spanning

studies have shown that the majority of higher education institutions worldwide were either completely or mostly shut down during the second half of 2020, with classroom teaching replaced by remote teaching (Pokhrel & Chhetri, 2021; Marinoni et al., 2020). The pivot from in-class to remote teaching proved challenging for many institutions. Comprehensive studies covering numerous institutions worldwide during 2020 found the key challenges for instructors during this time to be (a) access to technological infrastructure and tools, (b) pedagogical competence for remote teaching, (c) maintaining student privacy and confidentiality, and (d) controlling for student academic dishonesty Marinoni et al., 2020; Turnbull et al., 2021; Neuwirth et al., 2021).

However, the emergency remote teaching experience has also provided pedagogical and learning opportunities, most notably flexible learning possibilities and opportunities for instructors to explore different learning modalities such as hybrid or blended and various technologies for remote teaching (Pokhrel & Chhetri, 2021; Marinoni et al., 2020; Turnbull et al., 2021). In addition, many institutions reported they provided their students with opportunities for virtual mobility or collaborative online learning in lieu of onsite, in-person collaboration. This may explain why most institutions reported community engagement has increased, rather than decreased, during this emergency remote teaching period (Marinoni et al., 2020). In short, while the COVID-19 pandemic certainly has detrimental effect on teaching and learning in higher education, at least in the short term, the pandemic has also been a catalyst for pivoting to more sophisticated, flexible, and technologically advanced forms of teaching, at least for those institutions and instructors who were willing and able to learn and adapt their pedagogy.

2.2.3. Remote Teaching in Urban Studies: Challenges and Opportunities

For urban studies education, remote teaching has brought challenges and opportunities through physical, technical, and social aspects. Considering urban studies often involve the natural and built environment, a lack of physicality when teaching things usually requires an immersive experience. Traditionally, students in a traditional urban planning studio visit the site and have direct experience and observation of physical conditions and real-time situations (Pafka & Dovey, 2017). Such experience is difficult to replace through digital technology. Many urban studies curriculums are project-based, with local community-based organizations or city agencies as ‘project clients’. During the COVID-19 pandemic, it becomes difficult to get in touch with city agencies, stakeholders, and local neighborhoods due to such an abnormal situation. Students were experiencing obstacles to maintaining a live community and active communication once being physically separated. A lack of face-to-face communication further hampered the motivation and experience of peer learning and teamwork.

Meanwhile, the pandemic became a catalyst for remote learning and digital transformation in higher education with unprecedented scale and user coverage. Such disruption created

new opportunities for urban science studies. The remote learning experience makes students reflect on the critical role of information technology in cities and society during the pandemic. Socializing in a virtual environment forced us to consider the essential environmental and psychological benefits of physical space. Finally, the pandemic brought new questions and real-world challenges involving city planning, civic analytics, public health, and operational research. Such issues stimulate students' intellectual curiosity and motivation to pursue urban science and explore civic technology to address ongoing pandemic response issues. In this way, students can gain a deeper awareness of the social-technical complexities of contemporary cities involving equity, justice, fairness, and trust among people, organizations, and technology.

2.2.4. Teaching at Massachusetts Institute of Technology: Spring 2020–2021

About halfway through the spring 2020 semester, the Institute announced that the campus will shut down and that all spring classes will take place remotely (Mitra et al., 2021). In addition, grades for classes for the spring semester were changed to pass/fail only. The fall 2020 semester was fully remote for all students, but graded courses returned to being graded. The spring 2021 semester was in-person for senior students but remained fully remote for all other undergraduate students. For the urban studies course, the instructor switched to full remote learning a week before campus shutdown took effect. The instructor made lecture recordings available for students, had virtual office hours for students, and communicated with students via Slack, an online message platform. The instructor introduced special topics related to the COVID-19 pandemic, such as COVID-19 data visualization, ethical controversy in digital contact tracing, the role of urban mobility in the spread of virus, and equity issues and vulnerable population during the lockdown. The instructor made frequent use of breakout rooms and the chat function to help facilitate group discussion. Student teams continued working on their projects concerning the application of data science to urban challenges.

3. The Evolution of an Urban Studies Section in a First-Year Course: Creative Thinking in Digital Cities

At MIT, students choose their major of study towards the end of their first year; for this reason, the institute offers first-year students a selection of *first-year discovery classes*, which are not part of any degree requirements and allow these students to explore various domains and interests. These classes, or courses, are pass/no pass (rather than graded) and are limited to no more than three units of study.

During summer 2020, the leadership of the *New Engineering Education Transformation* (NEET) program at MIT commissioned the first author to design and deliver a new course, starting in fall 2020, to introduce first-year students at the Institute to the program. NEET is an undergraduate cross-departmental and project-centric program, open to all sophomores (2nd year students) at MIT. Students join NEET in their sophomore year and complete the program at the end of their senior year in an interdisciplinary track

(thread) of their choice: *Advanced Materials Machines*, *Autonomous Machines*, *Digital Cities*, *Living Machines*, or *Renewable Energy Machines* (Crawley et al., 2018; Crawley & Hosoi, 2019).

At the time of the study, the first author was the Lead Instructor for Digital Cities (DC), while the second author was the program's curriculum designer and lead instructor for the course described in this paper, titled *SP.248 – NEET Ways of Thinking*. The developing narrative of the course section described herein—*Creative Thinking in Digital Cities* (CTDC)—began at the onset of the COVID-19 pandemic in spring 2020 and has carried through to fall 2022. Table 1 summarizes the various iterations of SP.248.

Table 1

Summary timeline: Development and implementation of SP.248.

Semester	Course iteration	Modality	N students
Fall 2020	First	Remote	54
Spring 2021	Second	Remote	11
Fall 2021	Third	In-person	14
Fall 2022	Fourth	In-person	n/a

3.1 Summer 2020: Design and Planning of the Course and its Creative Thinking in Digital Cities Section

At the end of the Spring 2020 semester, the second author was tasked by NEET leadership to design a new three-unit pass/fail first-year course open to all undergraduate students with the programmatic aim of introducing students to the various NEET threads. Throughout the summer 2020 semester, the second author worked with other NEET instructors, including the first author, to design and develop an appropriate curriculum and pedagogy for this course. Each instructor is a domain expert for their specific thread. Eventually, the instructional team settled on a curriculum that introduced first-year students to domain knowledge and to ways problem-solving approaches related to the various interdisciplinary threads of the NEET program.

The learning objectives for the course were to introduce students to transdisciplinary ways of thinking & doing and to their application to interdisciplinary problems. This course was the first of its kind at MIT to center around thinking skills rather than around specific disciplines, domains, or problems.

In terms of pedagogy, the instructors opted for a case-based learning (CBL) approach. The origins of CBL are in professional education of medicine, business, and law (Allchin, 2013), but in recent decades this approach has also been applied of science and engineering learning settings (e.g., Addy et al., 2018; McWhirter & Shealy, 2020; Rhodes et al., 2020; Yadav et al., 2019). CBL uses specific occasions (cases) to contextualize the learning of a discipline or practice-specific knowledge. It is student-centered and requires the instructor to act as an expert guide rather than a source of

knowledge (Allchin, 2013). This approach can foster students' development of conceptual understanding along with their thinking skills, as well as the development of their interpersonal skills, when working in groups (Allchin, 2013; Savery, 2006). The application of CBL allows for varying degrees of learner autonomy (Kulak & Newton, 2014). The instructors chose CBL over other pedagogical approaches owing to its effectiveness in developing students' thinking skills and interpersonal skills, as well as its versatility of application, as the various cases suited different levels of learner autonomy.

The iterations of SP.248 which are described herein consisted of five two-week sections, with each section focused on a single thread or interdisciplinary field, one or two cases (described problems to be solved), and a single *way of thinking and doing*—algorithmic, creative, systems, or making. Ways of thinking and doing comprise a core principle of NEET, which was why it was chosen to center the new course around them. The course involved one hour of synchronous teaching (class time) a week via zoom, followed by two hours of out-of-class assignments, mostly in teams. Class time involved lecture portions, presentations, and individual & team-based activities, depending on the week. Every class included some student activity and no class comprised of just lectures.

Following a discussion between both authors, they chose creative thinking for the Digital Cities section of the course. This way of thinking and doing was chosen as it fits well with the open-ended aspect of many problems in urban science. Designing this section of the course involved (1) selecting and describing a real-world problem in urban science for the students to tackle, (2) developing instructional material, (3) designing student assignments, and (4) developing assessment for evaluating student performance.

3.2 Fall 2020: First Iteration of Course—Remote Teaching

Both instructors taught the CTDC section of the course, with 54 students completed this iteration of the course. Following the very first class of this course, which took place one week before the first class of its CTDC section, students self-allocated into teams of three or four, in which they remained throughout the course. Students were asked to prepare for the first week of this section by reading two popular science articles about the domain of urban science and planning. The general sequence of teaching and learning activities this section was as follows: (1) instructors introduced the domain and the challenge to students, (2) students practiced and implemented a technique for defining problems in a solution-neutral way, (3) students presented their problem definitions, and (4) students practiced and implemented a technique for generating creative solutions for their problem. Every stage in this sequence was followed by instructor feedback, either asynchronously via email or synchronously in class. Both instructors met the students once a week for 50 minutes on the Zoom video conferencing platform[1] for class, and students had two further hours a week to work on out-of-class assignments,

which were filled-out and submitted using Google Forms[2]. Table 2 summarizes the teaching and learning activities included in the CTDC course section. For an example of the products of one student team, see Table A in Appendix.

Table 2

Teaching and learning activities during the Creative Thinking in Digital Cities section of SP.248 – NEET Ways of Thinking

Period Duration	Activities	Student product
Before week1 Max. 2 hours	Individual students: read two short articles on the topic of urban planning and design.	-
Week1 class 50 minutes	Mini-lecture: The digital cities domain and introduction to the challenge Mini-lecture: How to define problems for creative problem-solving. Individual students: Define the problem	Responses to the five Ws: ● Who? The group of people most affected by the problem. ● What? The way in which that group of people is affected by the problem. ● Where? The real and/or virtual location/s in which the problem occurs. ● When? The event/s or period/s during which the problem occurs. ● Why? The cause and enablers of the event during which the problem occurs.
Week1 out of class Max. 2 hours	Student teams: Define the problem	Problem definition
Week2 in class 50 minutes	Student teams: present problem definitions Mini-lecture: Generate creative ideas by challenging implicit assumptions about problems Individual students: Challenge implicit assumptions about the problem definition	List of implicit assumptions List of ideas
Week2 out of class Max. 2 hours	Student teams: Refine and select ideas	Two most original ideas from the team with justifications One original idea, refined

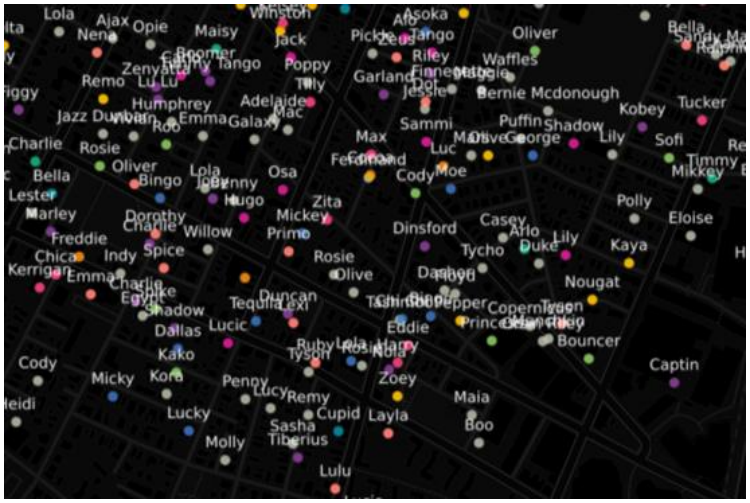
During the first class of this section of the course, instructors introduced students to an authentic challenge: how to facilitate dog walking in a US city during a time of social distancing. The challenge students tackled throughout this section was presented to them as follows:

"*The City of Cambridge is exploring an idea of utilizing urban open data to provide useful information for outdoor leisure activities while keeping social distancing during the COVID-19 pandemic. For example, the image shows the location of dogs around MIT campus. How can we create some relevant civic tech utilizing this data?*"

The authors phrased the challenge in a way that a typical client, rather than a scholar, would—in this case, a Cambridge Municipality employee. This challenge was chosen by both instructors as one which explicitly relates to the COVID-19 pandemic. In Fall 2020, many cities worldwide implemented a lockdown or 'shelter-in-place' policy to restrict physical activities in public spaces such as leisure walking, jogging, or social gathering. Some cities have local policies to respond to households' demand for dog-walking activities (Owczarczak-Garstecka et al., 2021; Vucinic et al., 2022; Carr et al., 2021). Before the pandemic, the city had digitized dogs' registration records as publicly available open data (Figure 1). Such data report the dog's approximate geolocation, age, breed, name, and physical features.

Figure 1

A screenshot of city dog registration records data



3.3. Spring 2021: Second Iteration of Course—Remote Teaching

11 students completed this iteration of the course. Both instructors taught the CTDC section of the course, with the same challenge and process as in the Fall 2020 iteration. Since the first iteration received an overall positive response from students, and its learning objectives were achieved, both instructors decided not to make substantial changes to this section.

3.4. Fall 2021: Third Iteration of Course—In-Person Teaching

In Summer 2021, the Institute announced that first-year students will be back on campus in Fall 2021. 14 students ended up completing the Fall 2021 iteration of the course. While

the curriculum for the CTDC section remained the same as during the first two iterations, the instruction changed into in-person teaching, where classes took place in one physical classroom, while out-of-class assignments took place as before. The teaching and learning activities did not change from the previous iteration; synchronous activities (class time) were adapted and implemented in a physical classroom. The first author was no longer teaching at the Institute, so the second instructor taught this section along with the Faculty Lead for NEET DC.

3.5. Fall 2022: Planned Fourth Iteration of Course—Hybrid Teaching

In Fall 2022, the Institute expected to continue in-person teaching. Based on lessons learned from the third iteration of the course (see '4. Discussion' below), this fourth iteration is expected to contain both in-person and remote parts, optimized for quality of teaching and learning. The new NEET DC Lead Instructor will co-instruct this section with the second author, based on a new challenge which will not be related to the COVID-19 pandemic.

4. Discussion

The two-week course section, *Creative Thinking in Digital Cities*, challenged instructors' facilitation of students' collaborative and creative problem-solving skills. These challenges were compounded by the course being a new one at the institute and remote teaching being new to both instructors. As a result, the authors were required to challenge pedagogical assumptions, reexamine their respective approaches to teaching, design a fully remote course, and learn how to use new instructional tools.

4.1. Successes and Areas for Improvement

The overall remote teaching and learning were successful, based on (a) measured learning outcomes, (b) retention rate of students, and (c) positive end-of-term voluntary subject evaluations by students. Three main factors contributed to the smooth remote or hybrid experience, including competent selection and use of digital technology, rigorous course planning and design, problem/challenge design, and continual formative assessment and feedback from the instructors. Stable broadband speed, user-friendly virtual communication tools, and computing equipment are essential for conducting online learning. We find out online teaching requires more detailed class planning with a precise schedule and clear agenda, especially when involving virtual face-to-face communication for teamwork. Finally, designing a meaningful and relatable problem is a key for students' creative thinking and collaborative ideation in a remote environment. In our case, students can quickly grasp the dog-walking challenge and its relevance to urban data science, civic analytics, community engagement, and public health measures during a pandemic.

Areas for improvement include more teaching parts to help students better understand the conceptual framework of data-driven urban operation, data science for public health, and smart city technology for public health surveillance and pandemic response (Lai et al., 2020). Considering the short

period of learning time (two weeks), we have significantly shortened the research phase of problem-solving. Such limitations may constrain students from gaining a fundamental understanding of the problems. Therefore, we believe that additional learning material pre- or post-course may support students in comprehending the urban challenge and its complexity. Some possible learning material includes pre-recorded mini lectures covering the topic with essential background knowledge and reading material reporting critical facts and relevant stories.

Overall, students found the challenge is multi-faceted with physical, social, and technical factors, yet very urban-centric, focusing on handling complex conflicts among personal demands, community interests, and urban policy. Such complexity and dynamics also reflect on students' solutions from data-driven policymaking, intelligent civic operation, evidence-based urban design, and information services. However, students may not know how such multi-parties and multi-disciplinary problem-solving processes work. Thus, it would be necessary to provide students with some short reading material as case studies to learn about the best practice and a general planning process. Finally, we believe a short quiz after the first week may improve students' preparation for collaborative problem-solving in class.

Although this pedagogical experience was successful overall, there is still a gap between data-driven and design thinking that constrains students from developing more holistic and systematic solutions integrating complex environmental, technical, and social-political considerations. Ultimately, this is the exact niche that the urban science discipline aims to tackle compared to traditional urban studies education.

4.2. Suggestions for Instructors

Remote settings pose difficulties for ascertaining students’ understanding of assignment guidelines. While in-person settings allow instructors to sense students’ body language and micro-expressions, and provide opportunities for spontaneous conversations after class, remote settings do not provide instructors with as much data about students’ level of understanding. This is where the in-class individual training assignment, which served as preparation for the out-of-class team assignment and followed the same format, provided both the instructors and the students with a way to make sure assignment guidelines were clear to all students. The instructors were able to see each individual response as well as a summary of students’ responses, which allowed the instructors to address common issues with specific items in the assignment form. In addition, each form included as a last, non-mandatory item which read “If there was anything you were not clear about with this assignment, please tell us here”.

Remote settings can create a non-engaging atmosphere for several reasons, including the fact that each student is physically on their own and spontaneous opportunities for social interaction are not common. Therefore, designing opportunities for students to engage with the course content, the instructor, and each other, in and out of class, are of particular importance in remote settings. This can be done in

many ways, but in CTDC, we did this by having students present their work during class and by having them work together in teams out of class. About 70% of the overall learning time in the first two iterations of CTDC was dedicated to some form of interaction rather than a lecture or recitation format, and two-thirds of learning time (out of class time) was dedicated to teamwork. Lastly, though these did not take part during the two weeks of the CTDC section of the course, the course did include individual reflections on learning progress, including on the CTDC section. These reflections were intended to encourage further student engagement with the course content.

Finally, the experience of moving back to in-person teaching has shown us that different teaching and learning activities work better in different modalities. Therefore, when the given the opportunity, instructors should consider optimizing synchronous with asynchronous teaching, and remote and in-person teaching. In-person, synchronous settings are most optimal for activities that require close interaction and exchange of ideas, while less interactive activities, such as lecturing, can be moved to a remote, asynchronous modality. In this way, instructors can maximize both teaching quality as well as their own, and their students', time.

5. Conclusion

In conclusion, this paper describes the intention, planning, processes, and reflections on teaching adaptation and innovation in a remote virtual environment, and how these activities have evolved along with our Institute's evolving response to the pandemic. This work contributes to new pedagogical approaches in collaborative problem-solving for urban studies education, adding new practices and case studies to the limited literature on the digital transformation of urban studies pedagogy. The COVID-19 pandemic brought unprecedented disruptions to the high education teaching and learning experience, requiring new tools, approaches, and forms of education to adapt to the remote environment during the public health crisis. For undergraduate urban studies education in particular, the COVID-19 pandemic brought opportunities for educators to address the 'new normal' of urban studies education. Such transformation not only responds to the technical constraints due to a lack of on-site learning, but also raises new questions to investigate the complex physical-social-technical evolution of cities.

References

ABET (2022). General criterion 3. Student outcomes from criteria for Accrediting Engineering Programs, 2018–2019.https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/#GC3

Acuto, M., Parnell, S., & Seto, K. C. (2018). Building a global urban science. *Nature Sustainability, 1,* 2-4.

Addy, T. M., Dube, D., Croft, C., Nardolilli, J. O., Paynter, O. C., Hutchings, M. L., ... & Reeves, P. M. (2018). Integrating a serious game into case-based learning. Simulation & Gaming, 49(4), 378-400.

Allchin, D. (2013). Teaching the nature of science. *Perspectives and Resources. St. Paul, MN: SHiPS Education Press*.

Ananiadou, K., & Magdalean, C. (2009). *21st Century skills and competences for new millennium learners in OECD countries.* OECD.

Arefi, M., & Triantafillou, M. (2005). *Reflections on the pedagogy of place in planning and urban design. Journal of Planning Education and Research, 25*, 75-88.

Barron, F. (1955). The disposition toward originality. The Journal of Abnormal and Social Psychology, 51(3), 478–485.

Berg, J. M. (2014). The primal mark: How the beginning shapes the end in the development of creative ideas. Organizational Behavior and Human Decision Processes, 125(1), 1-17.

Bozkurt, A., & Sharma, R. C. (2020). Emergency remote teaching in a time of global crisis due to CoronaVirus pandemic. *Asian Journal of Distance Education, 15*(1), i-vi.

Carr, D., et al., (2021). Dog walking and the social impact of the COVID-19 pandemic on loneliness in older adults. *Animals (Basel), 11*, 1852.

Crawley, E. F., Hosoi, A., & Mitra, A. (2018). Redesigning undergraduate engineering education at MIT – the New Engineering Education Transformation (NEET) initiative. In t*he American Society for Engineering Education (ASEE) Conference & Exhibition*. Salt Lake City, Utah.

Crawley, E.F., & Hosoi, A. E (2019). Moving forward with the New Engineering Education Transformation (NEET) program at MIT – building community, developing projects, and connecting with industry. In *The ASEE Annual Conference & Exhibition*. Tampa, FL.

Hélie, S., & Sun, R. (2010). Incubation, insight, and creative problem solving: a unified theory and a connectionist model. Psychological review, 117(3), 994.

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. *Educause Review, 27,* 1-12.

Ishida, T., & Isbister, K. (2000). *Digital cities: Technologies, experiences, and future perspectives*. Springer.

Jang, H. (2016). *Identifying 21st century STEM competencies using workplace data. Journal of Science Education and Technology,* 25(2), 284-301.

Jonassen, D. H. (2000) Toward a design theory of problem solving. *Educ. Technol. Res. Develop.*, 48(4), 63–85.

Kontokosta, C. E. (2021). Urban informatics in the science and practice of planning. *Journal of Planning Education and Research, 41*(4), 382-395.

Kulak, V., & Newton, G. (2014). A guide to using case-based learning in biochemistry education. *Biochemistry and molecular biology education*, *42*(6), 457-473.

Lai, Y., Yeung, W., & Celi, L. A. (2020). Urban intelligence for pandemic response: Viewpoint. *JMIR Public Health Surveill, 6*(2), e18873.

Lobo, J., et al. (2020). Urban science: Integrated theory from the first cities to sustainable metropolises. In *Report Submitted to the NSF on the Present State and Future of Urban Science*. NSF.

Marinoni, G., Van't Land, H., & Jensen, T. (2020). The impact of Covid-19 on higher education around the world. In *IAU Global Survey Report*. International Association of Universities (IAU)

McWhirter, N., & Shealy, T. (2020). Case-based flipped classroom approach to teach sustainable infrastructure and decision-making. *International Journal of Construction Education and Research*, 16(1), 3-23.

Mitra, A. et al. (2021). Pivot to remote teaching of an undergraduate interdisciplinary project-based program: Spring–Fall 2020. In *The ASEE 2021 Annual Conference* 2021: Montreal, Canada (Conference held online due to COVID-19 pandemic).

National Research Council. (2012). Education for life and work: Developing transferable knowledge and skills in the 21st century. Washington, DC: National Academies Press.

Nedelkoska, L., & Quintini, G. (2018). Automation, skills use and training.

Neuwirth, L.S., Jović, S., & Mukherji, B. R. (2021). Reimagining higher education during and post-COVID-19: Challenges and opportunities. *Journal of Adult and Continuing Education, 27*(2), 141-156.

Owczarczak-Garstecka, S. C., Graham, T. M., Archer, D. C., & Westgarth, C. (2021). Dog Walking before and during the COVID-19 Pandemic Lockdown: Experiences of UK Dog Owners. *International Journal of Environmental Research and Public Health, 18*(12), 6315.

Pafka, E., & Dovey, K. (2017). Urban Design Pedagogy. In *Mapping Urbanities* (pp. 268-277). Routledge.

Pokhrel, S., & Chhetri, R. (2021). A literature review on impact of COVID-19 pandemic on teaching and learning. *Higher Education for the Future, 8*(1), 133-141.

Rhodes, A., Wilson, A., & Rozell, T. (2020). Value of Case-Based Learning within STEM Courses: Is It the Method or Is It the Student?. CBE—Life Sciences Education, 19(3), ar44.

Runco, M. A. & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Res. J.*, 24(1), 92–96.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *The interdisciplinary Journal of Problem-based Learning, 1*(1), 9-20.

Scott, C. L. (2015). The futures of learning 2: What kind of learning for the 21st century. UNESCO Education Research and Foresight. Paris, France.

Turnbull, D., Chugh, R., & Luck, J. (2021). Transitioning to E-Learning during the COVID-19 pandemic: How have Higher Education Institutions responded to the challenge? *Education and Information Technologies, 26*(5), 6401-6419.

Vucinic, M., Vucicevic, M., & Nenadovic, K. (2022). The COVID-19 pandemic affects owners walking with their dogs. *Journal of Veterinary Behavior, 48,* 1-10.

Wengrowicz, N., Swart, W., Paul, R., Macleod, K., Dori, D., & Dori, Y. J. (2018). Students' collaborative learning attitudes and their satisfaction with online collaborative case-based courses. *American Journal of Distance Education*, *32*(4), 283-300.

World Economic Forum. (2016). The future of jobs: Employment, skills and workforce strategy for the fourth industrial revolution. In *Global Challenge Insight Report* 2016. Geneva.

Yadav, A., Shaver, G. M., & Meckl, P. (2010). Lessons learned: Implementing the case teaching method in a mechanical engineering course. Journal of Engineering Education, 99(1), 55-69.

Appendix: Products of one student team

Table A contains examples of student products for each assignment of the CTDC section of SP.248 in fall 2020. The examples for individual student products are taken from the same student, while the examples for student team products are taken from the same student's team. These student products are shared under approval of the MIT Institutional Research Board E-2532.

Table A

Products from one student team during the fall 2020 iteration of SP.248 – NEET Ways of Thinking Creative Thinking in Digital Cities section.

Activities	Student product
Individual students: Define the problem	Responses to the five Ws: ● Who? The group of people most affected by the problem. [Response: Cambridge residents.] ● What? The way in which that group of people is affected by the problem. [Response: Unable to participate in leisure activities.] ● Where? The real and/or virtual location/s in which the problem occurs. [Response: City of Cambridge.] ● When? The event/s or period/s during which the problem occurs. [Response: March of 2020 to present day.] ● Why? The cause and enablers of the event during which the problem occurs. [Response: Social distancing.]
Student teams: Define the problem	Problem definition [Response: During the COVID 19 pandemic, residents within the City of Cambridge are unable to complete leisure activities while social distancing despite FDA regulations requiring residents to stay apart.]
Individual students: Challenge implicit assumptions about the problem definition	- List of implicit assumptions [Response: There are very limited walking routes. The dogs need to be walked.] - List of ideas [Response: Create a vaccine for the corona virus so that people no longer have to social distance. Create a time table for when certain residents can alternate and walk their dogs.]

Table A (Cont.)

Products from one student team during the fall 2020 iteration of SP.248 – NEET Ways of Thinking Creative Thinking in Digital Cities section.

Activities	Student product
Student teams: Refine and select ideas	- Two most original ideas from the team with justifications [Response: #1 – A platform that allows scheduling, as well as provides estimates of population densities in certain areas. It is a way to assist members of the community in tackling the current health and safety challenges presented by the COVID-19 pandemic that has not yet been implemented. #2 – Give people 6ft hamsterballs to roll in so that they stay apart. Have you seen it??? This novel idea not only allows others to stay safe as they traverse the city, but also develops a new leisure activity for those looking for new hobbies during the pandemic.] - One original idea, refined [Response: The Cambridge community can use an application to keep track of how many people plan to go outside for leisure activities at any given time, as well as where they plan to go. The app will have a map that doesn't disclose personal information such as identity, but instead provides a rough estimate of how many people are in a certain area. As a result, they will be able to form a cohesive scheduling system that reduces the number of people out at any time, thus reducing the risk of spread. This will be effective since people who are in the same community tend to visit similar areas, so the overall number of people visiting a location at a given time would balance out. While not everyone may participate in this app, it will still reduce contact rate, as well as help those who use it with better decisions. This would be especially effective for the younger generation, who are more prone to going outside.]