# **Evaluating Students' Perceptions of Online Learning with 2-D Virtual Spaces**

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## **ABSTRACT**

The COVID-19 pandemic led the majority of educational institutions to rapidly shift to primarily conducting courses through online, remote delivery. Across different institutions, the tools used for synchronous online course delivery varied. They included traditional video conferencing tools like Zoom, Google Meet, and WebEx as well as non-traditional tools like Gather. Town, Gatherly, and YoTribe. The main distinguishing characteristic of these non-traditional tools is their utilization of 2-D maps to create virtual meeting spaces that mimic real-world spaces.

In this work, we aim to explore how such tools are perceived by students in the context of learning. Our intuition is that utilizing a tool that features a 2-D virtual space that resembles a real world classroom has underlying benefits compared to the more traditional video conferencing tools. The results of our study indicate that students' perception of using a 2-D virtual classroom improved their interaction, collaboration and overall satisfaction with an online learning experience.

# **CCS CONCEPTS**

• Applied computing  $\rightarrow$  E-learning; Collaborative learning; Distance learning; Interactive learning environments; Computer assisted instruction; • Social and professional topics  $\rightarrow$  Computing education.

# **KEYWORDS**

e-learning, virtual classroom, gather town, student perception, online education, interactive learning, active learning

# 1 INTRODUCTION

The COVID-19 pandemic highlighted the need for video and audio conferencing tools designed to support instructors teaching courses

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online and adopting the active learning instructional method [12, 19]. Instructors were not just looking for ways to engage students during online class meetings, but also needed tools to support interaction, participation in collaborative work, and development of relationships among students. Students learning online face additional challenges compared to in-person learning, such as physical separation, feeling of isolation, lack of support, and feeling disconnected.

Krause et al. [7] argued the importance of providing students with an experience that goes beyond the traditional focus on academic performance. They noted that a positive student experience arises from having a sense of connection within the classroom and the university. Students feel the need to be part of a learning community where they feel involved and have a social presence. As this is true for both in-person and online learning, technologies used to create virtual classrooms need to be cognizant of this requirement.

Gamification and game-like features have been used by educators to engage and motivate students in Computer Science (CS) courses and beyond [6, 9]. Applications designed for learning, like Duolingo [1], have also used gamification strategies to motivate users to learn new skills. We can extend this to the context of synchronous virtual classrooms and ask the question: what other game-like features can be used to engage and motivate students in such environments? Minecraft, Sims, and World of Warcraft are examples of games with broad appeal. Some of the key features of these games is that they are based on virtual worlds where users are represented using avatars that have the ability to move around the virtual space. While such tools have been used in education — for example, the game Minecraft has been used to address barriers to entry in the computing field [3] — they have not been examined in the context of synchronous virtual classrooms.

Various platforms have incorporated virtual worlds, gamification and video calling to create immersive environments that aim to increase user engagement. One such platform is *Gather.Town* [2]. Our research focuses on examining *students' perception about their learning experience when using a video calling tool that features a 2-D virtual space versus one that does not.* Compared to 3-D technologies that have the potential of offering a more immersive experience (e.g., [5, 15]), 2-D tools provide a lightweight approach to key spatial interaction affordances in a virtual world. In particular, proximity provides physical interaction analogues for spatial cues and boundaries using interaction distance.

In this paper, we report on students' experience in several computer science courses at the University of North Carolina at Charlotte, a U.S. public university, that piloted the use of Gather.Town, a web-based video calling conference tool that uses a 2-D virtual space to facilitate interactions between participants.

Through this work, we address the following research questions:

- (1) How do students perceive their learning experience when using a video calling tool that utilizes 2-D virtual spaces in synchronous online course delivery?
- (2) How do students perceive the use of a video calling tool that utilizes 2-D virtual spaces in synchronous online course delivery influences their learning?

Our results show that using 2-D virtual worlds for synchronous course interactions can positively enhance students learning experience by facilitating interactions with peers and instructors in a more natural and fun way.

The rest of this paper is organized as follows. We discuss related work in Section 2 and introduce Gather. Town in Section 3. We provide details about our study setup and evaluation parameters in Sections 4 and 5, respectively. We present and discuss our results in Section 6. Finally, we present our conclusions and discuss future research directions in Section 7.

### 2 RELATED WORK

Research focused on this topic looks into the synchronous classroom environment as opposed to asynchronous online delivery
of course material, which may provide a very different environment and learning experience. Adding synchronous components
to online courses can enhance meaningful interactions [16]. Synchronous Virtual classrooms are made possible by online tools that
enable students and instructors to communicate synchronously.
These tools support interactions between participants in the virtual classroom as if they are in person, using features such as text
chat, audio, and video. Additional features like screen sharing, live
polling, interactive whiteboard, expressing emotions through emoticons, break out rooms for group activities, etc. can help increase
interaction and engagement which are some of the major challenges
in online education.

Martin et al. [13] investigated interactions within synchronous virtual classrooms and outlined four types of interactions that occur in such settings: learner-learner, learner-instructor, learner-content, and learner-interface. They analyzed the interactions that occur in the virtual classroom and found that most of the interactions were academic in nature. They also reported on students' perception of these interactions and what tools instructors can use to enhance these interactions. An article published by Cardiff University provides advice for online synchronous education, mentioning the unique challenges the environment poses [10]. According to this article, the students' physical / real learning environment can be distracting, so additional effort should be made to engage students in the virtual learning environment. Furthermore, the article suggests making the virtual environment more informal and approachable in order to engage students and encourage participation. This article only looked at video calling tools and did not look at how

virtual worlds with 2-D spaces could meet these suggestions for an effective synchronous classroom environment.

Other research has looked into virtual tools in educational contexts like teacher training and professional development. For example, Muir et al. looked at using the virtual platform *Second Life* to prepare pre-service teachers for classroom management by modeling a diverse range of student needs [15]. Dalgarno et al. looked at how virtual role-playing in Second Life can be used to train teachers before they are placed in a classroom [5]. Second Life was also analyzed for its effectiveness in teachers' professional development.

Learning strategies have been examined in the context of underrepresented minorities [17] which has extended to the use of virtual worlds for learning. Warden et al. looked into whether these environments disadvantage non-gamers and women. Specifically, they examined whether these groups were disadvantaged when using the virtual world *Open Wonderland* for their education and concluded that it did not disadvantage them in a significant way [20].

Researchers have also looked into how to create a virtual world for education utilizing more immersive technologies such as virtual reality (VR). Sharma et al. looked at developing a virtual classroom and utilizing new technology like VR, with promising results [18]. Their work focused on the design of a new tool and evaluating the tool itself as opposed to evaluating users' reactions to the tool. Researching the use of virtual worlds for online education is not new. Maher introduced the concept of designing a virtual campus based on a virtual world [11]. Maher defines virtual worlds as "networked environments that look like the physical world, and create a sense of place for the person communicating, navigating, and doing things in the virtual world". This research examined designing a virtual campus from an architectural standpoint. Maher believed that virtual worlds could foster a sense of community, like being on a real campus, and create more spontaneous interactions between community members. This work addresses a gap in research of how students perceive virtual worlds, especially in synchronous virtual classrooms. Our research utilizes newly released virtual world platforms to understand how students perceive the learning experience when such platforms are used for synchronous online education.

Virtual meeting tools that offer a virtual world are rather limited. Our study is based on courses that use Gather. Town as the tool for conducting synchronous online sessions. Given that Gather.Town and these types of meeting environments are new tools, little research has been done to determine whether it fulfills Maher's goals [11] for a virtual world used for education. McClure et al. reported on a case study on students' and educators' experiences using Gather. Town in a self-paced distance learning course [14]. Their results showed that 86% of the 7 students that responded to a survey found the tool to be better than other distance-learning tools and 100% (n=5) of the educators favored the use of Gather. Town. They also asked participants to rate some elements of the tool in relation to communication, use of interactive materials, navigating the space and aesthetics. They found that the most important element to both students and educators was the the ability to discuss with educators. Specifically related to Gather.town, Latulipe [8] reported on the use of Gather. Town in response to the COVID-19 pandemic. Latulipe looked at using Gather. Town for team-based learning in a

CS1 course and highlighted how Gather. Town makes it easy to create an active learning environment. This research primarily covered the design of a virtual classroom in Gather. Town and not the impact it had on learning. Our research aims to examine how Gather. Town affects students' perception of learning and how 2-D virtual worlds impact the online classroom.

# 3 THE TOOL: GATHER.TOWN

Gather.Town is a video conferencing tool, accessible through a Web browser, that is based on spatial interaction. It provides a virtual space that consists of a 2-D map and allows groups of participants to hold separate conversations in parallel through personal avatars that are placed in proximity to each other. The tool gives space owners the ability to design their spaces to resemble physical locations, with the ability to include tables, chairs, plants, and other items in their virtual rooms. For example, the classroom design used for this research (shown in Fig. 1) features a podium area, multiple tables for student groups, a conference room and lounge area. The tool also supports creating sections in the virtual space where participants can place their avatars and interact with every participant whose avatar is also in that section.



Figure 1: A virtual space in Gather. Town used as a classroom in five online classes at the University of North Carolina at Charlotte

Interaction between participants is supported through audio, video, chat and screen sharing features. The tool's main feature, "Interaction Distance", launches a video call between users whose avatars are in proximity to each other in the virtual space. As the users' avatars walk away from each other, their video and audio quality fades out, mimicking an in-person interaction. This allows participants to easily join and leave side conversations. Gather. Town is similar to other video conferencing tools in that it allows each participant to control their audio and video feeds, giving them the flexibility to choose how they interact with other participants.

# 4 SETUP

In this paper, we discuss the experiences from five computer science courses at a large public university in the U.S. that used Gather.Town in Spring 2021. The department purchased one subscription to Gather.Town to support these courses, and thus, multiple faculty utilized the same virtual classroom shown in Fig. 1. At the start

of the semester students registered for any of these courses were given a PDF with instructions on how to access the space and some tips on how to navigate and access the different features in the tool. As described in Section 3, the classroom space was designed to reassemble an actual classroom designed for active-learning. Faculty used Gather. Town for various synchronous activities within the five courses, as described below.

- C1: This course is a freshman-level intro to CS course with 55 students. The course is designed as a flipped and active learning course where students watch videos and complete interactive readings outside of class and class times are used for team-based learning where students participate in interactive quizzes, and work on problem solving activities. This course also has a lab component where students complete hands-on activities collaborating with other students.
- C2: This course is a junior-level software engineering course with 126 students. The course is offered as a flipped and active learning course. During class meetings, students work in small teams on activities related to a semester-long project.
- C3: This course is a junior-level operating systems and networking course with 120 students. This course is organized as a flipped classroom, with lectures delivered asynchronously via videos, interactive tutorials and readings. Class time is used for interactive quizzes and activities where students work in small groups. Gather.Town was used for synchronous class meetings three times a week. Groups were assigned table numbers within the Gather.Town space.
- C4: This course is a senior-level human-centered security course with 135 students. The course is flipped, where students watch lecture videos asynchronously and use in-class time for small group activities and to work on group assignments and projects. Groups were assigned a table number, and worked around their virtual table in the space.
- C5: This course is a graduate-level Human Centered Design course with 26 students. During class, students work in teams on activities designed to apply the knowledge they gain through watching course related videos outside of class. They use time in class to work on their semester projects through guided activities, which require students to get repeated feedback/critique from one of the instructors or from another team sitting at a different table.

## 5 EVALUATION

Students in all five courses were asked to respond to a voluntary and anonymous student experience survey at the end of the semester as a post-course questionnaire. The survey asked the students to compare their course experience using Gather. Town to other course experiences that used traditional video conferencing tools such as Zoom or WebEx (these were the two main video conferencing tools adopted and recommended by our university). We also invited students to participate in a short interview study with one of the researchers and asked them to reflect on their classroom experience. We were interested to see how easily students felt they were able to connect with peers and instructors and how comfortable they felt with the tool.

The student experience survey asked participants nine questions using a 1 to 5 Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). We asked the following questions:

- (1) Using Gather.Town increased my interest / desire / motivation to attend the course meetings.
- (2) I felt more connected to my peers during course meetings.
- (3) I felt more connected to the instructor during course meetings.
- (4) I felt comfortable interacting with other course participants in gather.town.
- (5) It was easy to get assistance from the instructional team in gather.town.
- (6) It was easy to get assistance from my peers in gather.town.
- (7) It was easy collaborating with my peers to complete group activities in gather.town.
- (8) I enjoyed the course meetings in gather.town more than other traditional virtual meeting tools (e.g. Zoom, WebEx).
- (9) Using gather.town influenced my learning in a positive way.

The end of the survey also included open-ended questions that allowed students to respond in paragraph format, using their own words to explain their experiences. We asked them to explain in what ways they thought Gather. Town influenced their learning and whether they had any suggestions on how to improve the use of Gather. Town in future semesters.

### 6 RESULTS AND DISCUSSION

By the end of the study, we had a total of 175 responses to the survey. In our discussion of the responses to Likert scale questions, we group responses of 4 (Agree) and 5 (Strongly Agree) together indicating agreement and responses of 1 (Strongly Disagree) and 2 (Disagree) indicating disagreement. Our findings are in line with [14] in that students were generally positive regarding attending course meeting in Gather. Town. 56% of students agreed that Gather. Town increased their interest, desire, or motivation to attend, compared to 14.37% that disagreed.

The survey questions covered three themes: connection to peers and instructors, collaboration and support, and enjoyment. We measured this by recording the number of responses in each category on the Likert Scale for related questions and grouping them as a whole to generate percentages. The first theme focusing on a sense of connection to peers and instructors corresponds to questions 2 and 3 listed in Section 5. Figure 2 shows these results, which follow a similar pattern as our overall observation, with 59.7% of students agreeing that Gather. Town helped them connect better with students or instructors.

The second theme was about being able to collaborate and seek assistance in Gather. Town, which corresponds to questions 5, 6, and 7. As shown in Fig. 3, 74.1% of students agreed that Gather. Town significantly increased access to instructors and peers for questions and collaboration. This indicates that virtual classroom interactions were enhanced in Gather. Town as apposed to traditional video conferencing tools. The third theme was finding a sense of fun, enjoyment and overall satisfaction with Gather. Town, which corresponds to questions 1, 8, and 9. As shown in Fig. 4, 62% of students agreed with feeling that Gather. Town had a sense of fun and they were satisfied with the environment.

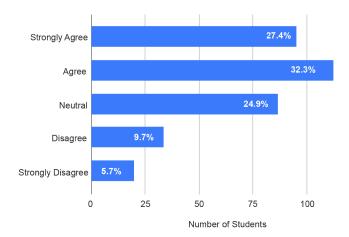


Figure 2: Positive Effect on a Sense of Connection in Gather.Town (Q. 2, 3)

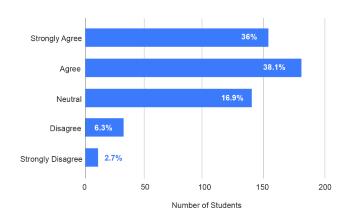


Figure 3: Ease of Seeking Assistance and Collaborating in Gather.Town (Q. 5, 6, 7)

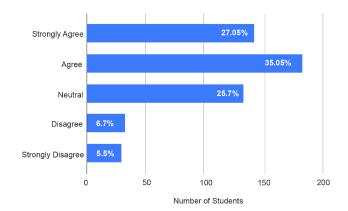


Figure 4: Sense of Fun and Satisfaction with Gather.Town (Q. 1, 8, 9)

To further understand students' perceptions we examined whether any correlations existed between the different themes. We utilized

Pearson Correlation and examined all correlation pairs. We found that there was a strong correlation (0.74 and p-value 0.059) between interest / desire / motivation to attend the course meetings and a sense of feeling more connected to peers. Another finding was the strong correlation (0.79 and p-value 0.112) between how students felt about their connection to teachers and their perception of how using Gather.Town influenced their learning in a positive way. This was also the case with students' perception of Gather.Town's positive influence on learning and their interest / desire / motivation to attend the course meetings. Our results are inline with research by Aguilera-Hermida who suggests "The attitude of the students and their cognitive engagement were highly related during online learning due to COVID-19" [4]. Being engaged by Gather.Town likely led students to be more motivated in their coursework and created the perception of a good learning environment.

We note here that from the 175 responses, 20 students indicated that they were registered for 2 or more of the courses that utilized Gather. Town. We examined whether there was any correlation between students' responses if they belonged to this group versus the ones that did not. There was no significant differences between the two groups, which indicates that the level of exposure to the tool did not affect students' perception.

For the qualitative analysis using the data we collected in the open-ended questions on the survey and two interviews we started by conducting a thematic analysis. In this analysis two researchers coded the data to look for common words and phrases and group common sentiments. After consolidating the two researchers' findings, the thematic analysis revealed four main themes.

First, students enjoyed the 2-D virtual environment and felt it contributed to a classroom feel. One student commented, "I really liked the ability to talk at my table as we were not able to do that with online classes this semester. It made me feel like I was in the classroom again!". During individual interviews a participant also mentioned the tool giving them a sense of place saying that it, "gave us sort of a concrete representation of being in a classroom rather than being at my desk in a strange nebulous mental space." Whereas, they felt with Zoom, "it sort of feels like anything else I do online. Except for it doesn't have that homey feeling of like if you're in a voice call with people you've known for years. It just sort of feels like you're in a strange middle space where yeah I'm in my room or I'm on the couch but I'm also in like this I'm like there's a sense that I'm in a classroom but not I'm not in a classroom".

A second theme was that Gather.Town allowed for collaboration and effective group work. A student said, "Gather.town was fun to use and made it much easier to interact with my group in class while still being able to communicate with my professor/TAs." Many other students also pointed out enhanced interactivity. A third theme was ease of access to the instructional team. According to one student, "The professor was easily visible and could switch between talking to the class and joining individual conversations. TAs were more easily accessible as well. I liked being able to walk around and look for them if I needed help instead of just waiting in a zoom chat." Of the 113 students who responded in the free response section, 13 mentioned ease of access to the instructional team. Finally, students noted that Gather.Town introduced an element that was fun and game-like. "Gather.Town put a new twist on group learning that reminded me and my peers of games we played

when we were younger," a student commented. It also introduced a sense of fun through game-like elements. An interview participant commented, "In my software engineering class last year [...] that class was in Gather. Town and we like decorated our space. We got to like decorate our space, we got to like do fun things like with our team and our team just like really came together." While students' responses to Gather.Town were generally positive, some downsides to using the tool for virtual instruction also came up during qualitative analysis. The main downsides mentioned were primarily focused on software bugs in the platform or other issues and limitations due to it being in a beta stage. A student said, "It made my computer run very slow and struggle to load anything so it was hard to do any work." Another student said, "It was good to work in groups but it was kind of buggy and I prefer Zoom." However, only a small number of students reported major technical issues and the experience itself was positive for the majority of students, with one student commenting, "I've used webex, zoom and now gather.town and I will choose gather.town over the other two every possible chance". It is worth nothing the tool has limitations when it comes to accessibility. For example it does not support closed captioning and requires special considerations for users with low vision or blindness. Despite these limitations students found value to the tool. One student noted "Having a physical space in front of you really helps people with ADHD or similar issues where they need to visualize in order to properly function." Another student highlighted how such tool can increase inclusivity as one student stated "I'm non-binary and it's always hard for me to use webcams and mics because people make assumptions about the way I happen to look or talk, gather.town was nice in that it let me manage my appearance even if it wasn't necessarily the intention of its usage (and it wasn't perfect, but still better than the alternatives for that)."

One of the main motivations for instructors to adopt this tool was the design of their courses. Many courses that adopt an active-learning instructional strategy include learning materials that are dependent on student-to-student interaction and teamwork. It was important to use a tool that can facilitate this in a virtual setting. Students explicitly contrasted Gather.Town with the *breakout room* feature available in traditional video conferencing tools. For example, one student stated Gather.Town was "A more interactive workspace than breakout rooms in Zoom." Another student said "Classes being online is hard to combat and keep students engaged, I do not really know any methods that could help make it better. Gathertown was better though in the aspect of not sending us off in breakout rooms for everyone to just leave."

To further explore these responses, we utilized Natural Language Processing (NLP) techniques. While we conducted this analysis on all the open ended questions in the survey we report here on the results from the data collected in the first open ended question as it directly relates to our second research question. Our intention is to understand what students thought influenced their learning in these environments. For this analysis stop words were removed first, then a variety of analyses were performed to look at common words and their importance in the dataset. Using the Python Natural Language Toolkit (NLTK) we looked at matrices created from a term frequency—inverse document frequency (tfidf) vector, which gave us the top 15 most important words across the whole dataset. The question that is analyzed was, "Briefly explain

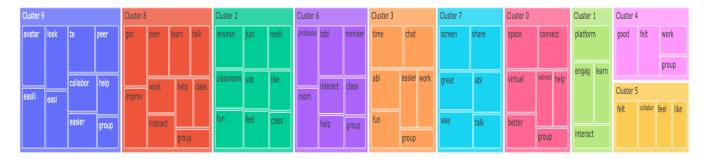


Figure 5: Treemap displaying the 10 clusters of student responses using the top 10 words appearing in each cluster based on their TFIDF values.

in what ways gather.town influenced your learning?". The overall frequency of each word in the data set was also recorded. Words like "group", "interact", "help", "easier", and "learn" were noted as frequent and/or important in the dataset. These words are consistent with the themes that were revealed by the thematic analysis.

To visualize the results from the NLP analysis Scikit-learn Python library was used to perform clustering based on the tfidf vector of the student responses. The number of clusters was set to 10 and Figure 5 shows the top ten words that appear in each cluster based on their term-frequency. We can see from these results that clustering highlighted similar themes revealed by the thematic analysis. Ideas like collaboration, group work, interaction and seeking help are noticeable in various clusters. Especially interesting are clusters 6 and 9. Cluster 6 shows a theme of collaboration/enhanced group work, which mirrors the thematic analysis mentioned previously. Cluster 9 mirrors the thematic analysis as well showing a theme of Gather. Town being easier to seek help from TAs/instructors.

# 7 CONCLUSION AND FUTURE WORK

Even as students start to return to the classroom, virtual instruction will continue to be present in some form. Due to its increased flexibility, especially for non-traditional students, it will likely still be utilized by many institutions. If students are to continue learning online, improvements should be made. A digital environment is inherently different from an in-person classroom. However, efforts can be made to find tools that students enjoy using and ones that help them engage with the content, seek help easily from the instructional team, and collaborate with their peers and teammates. This research suggests that a 2-D virtual learning environment positively affected:

- engagement through its use of game-like features and increased level of interactivity;
- collaboration with peers and interactions with the instructional team, making it easier for students to seek help;
- and satisfaction with the learning experience because of the engaging virtual environment and an added sense of fun.

This study was conducted in five courses within the same discipline in the College of Computing and Informatics at the University of North Carolina at Charlotte, which is a limiting factor in terms of data diversity. Future work can look into collecting data in courses from more diverse disciplines. This study focused on students' perception and satisfaction, but did not explore whether this tool impacted students' academic performance, as measured by course or activity grades. While student perception is an important measure for success, we believe academic performance is an equally important outcome. Another important and interesting perspective to report on would be the instructors' perspective and how these tools affect their classroom practices and attitudes. As the adoption of such tools increases, such a study would become more feasible.

Furthermore, as this research was conducted during the summer, we were not able to gather enough responses from students to form a focus group, which would provide additional data and is something we hope to incorporate in future studies. There are also many other academic contexts where Gather. Town could be used and its effectiveness studied. These include tutoring, office hours, one-on-one meetings, student orientations, and social events. In this paper, we reported on our initial study of the effect of 2-D virtual spaces on online education. More research should be done to examine its effect, but this preliminary research suggests 2-D virtual spaces give students a perceived positive learning experience with enhanced collaboration, access to instructors and TAs, and a sense of fun.

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