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Stop Talking and Type: Mentoring in a Virtual and Face-to-Face Environment

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Abstract Virtual environments allow users to explore complex concepts using simulations of real-world problems. In order to examine whether having mentors communicate with players through a virtual chat program rather than face-to-face changed anything about the players’ experience, this study compared a virtual chat and a face-to-face condition of the epistemic game, Urban Science. 21 high school aged players were randomly assigned to either the virtual chat or face-to-face condition, and all players played Urban Science for 10 hours. As part of the game, they participated in six reflection meetings led by their mentor, completed intake and exit interviews, and wrote a final proposal. Using discourse analysis, epistemic frame theory, and epistemic network analysis, this paper examines the mentors’ and players’ reflection meeting discourse and the players’ interviews and final proposals and asks whether there were differences in discourse, outcomes, or engagement levels between the two conditions. This study concludes that virtual mentoring can be just as effective as face-to-face mentoring and suggests that mentoring via chat is a viable method for mentoring in the context of epistemic games.

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Abstract
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Introduction
Virtual environments have the potential to allow young people to explore complex concepts in simulated form. In simulations, complex social and environmental problems that are too expensive, dangerous, or difficult for players to solve in the real world can be appropriately scaffolded in a dynamic model, giving young people opportunities to more easily interpret the interconnections in the model and develop professional thinking. Virtual environments also have the potential to simplify logistics by providing students with interactions with a variety of virtual non-player characters (NPCs), which could make the virtual environment more widely available in schools and other educational environments.

This paper examines a virtual environment called Urban Science, an epistemic game designed to simulate an urban planning practicum experience (Author1, 2010). In Urban Science novices, called players, take action in a supervised setting and reflect on their results with peers and mentors. The mentors facilitate the novices’ work in the practicum by scaffolding tasks the novices are not yet ready to
undertake and help them reflect on that work. Following this practicum model, mentors and players interact through planned reflection meetings where the mentor helps players discuss previously completed activities and plan next steps in the project.

This paper examines mentors’ and players’ reflection meetings in a face-to-face and a virtual condition and asks:

1. Was the mentors’ discourse during the reflection meetings different between the two conditions?
2. Was the players’ discourse during the reflection meetings different between the two conditions?
3. Were the players’ outcomes different between the two conditions?
4. Was the players’ level of engagement different between the two conditions?

Theory

There is a growing body of research that suggests that video games (used in both formal and informal environments) can support learning (Author1 & Author2, 2009; Barab & Dede, 2007) because games allow young people to explore complex concepts in simulated form. Virtual environments allow young people to solve simulations of real-world problems and learn real-world skills, knowledge, and values in a virtual world. In the simulations, complex social and environmental problems can be appropriately scaffolded in a dynamic model, giving young people opportunities to more easily interpret the interconnections in the model and develop professional thinking. Since models are abstractions of reality, variables are intentionally left out in order to simplify the system, allowing players to discover the missing connections needed to accurately convey the real interactions and deal with specific questions more fully. In other words, the model simulates problems that are too expensive, dangerous, or difficult for players to solve in the real world by scaffolding some of the professional vision to make it possible for the players to get a handle on the complex problems.

Even with a complex model available, logistical concerns, such as identifying experts with adequate experience to mentor players make virtual environments difficult to implement in educational settings. Virtual environments have the potential to simplify logistics by providing students with interactions with a variety of virtual non-player characters (NPCs). In virtual environments, the NPCs can play the role of mentors, community members, colleagues in a fictitious firm, or any number of other roles. The NPCs’ performance can be automated, lowering the logistical overhead and making the virtual environment more widely available.

One type of virtual environment designed specifically for young people to explore complex concepts in simulated form with lower logistical overhead is the epistemic game. In epistemic games, novices inhabit a virtual environment in which they learn the epistemic frame—the combination of linked and interrelated skills, knowledge, identity, values, and epistemology—of a particular profession by simulating professional training (Author2, 2007). Novices are supported by peers
and mentors and by simulations that scaffold some of the skills and knowledge necessary for young people to build professional epistemic frames. Mentors in epistemic games facilitate cycles of real-world learning through frequent and strategically-placed reflective conversations with the novices (called “players” in epistemic games) about their authentic tasks. Mentors model a professional epistemic frame by asking players to reflect on what worked, what did not work, and why and scaffolding a way of seeing and solving problems that the players can adopt (Nash, 2010).

In epistemic games, mentoring has traditionally been conducted face-to-face with players. However, face-to-face mentoring has high logistical overhead and limits the availability of the game. One way to simplify logistics might be to have mentors communicate with players virtually. However, some are skeptical of virtual mentoring and argue that when communication goes electronic, the richness associated with face-to-face conversation diminishes and a considerable amount of information is lost (Bierema & Merriam, 2002). Brennan and Lockridge (2006) argue that in chat-based interactions, mentors have no access to the players’ body language, tone of voice, or the variety of other signals that can only be detected in a shared physical environment, and as a result, miscommunication can occur.

On the other hand, Whittaker (2002) found that people communicated clearly and easily over a wide variety of media, including virtual chat programs. Bierema and Merriam (2002) argue that e-mentoring is boundaryless in that it opens the possibility for interactions that cross geographical and cultural boundaries. According to Harrington (1999), virtual mentoring provides people from rural or remote areas with opportunities that would otherwise be unavailable with traditional mentoring. Bierema and Merriam (2002) also suggest that virtual mentoring is egalitarian in that it has the potential to cross barriers of race, gender, geography, age, and hierarchy that are rarely crossed in traditional mentoring contexts. They argue that since computer-mediated interactions can offer a context for interactions between diverse parties, virtual mentoring holds “the potential to erode some of the traditional power dynamics that tend to structure mentoring relationships” (Bierema & Merriam, 2002, p. 220).

Virtual mentoring also has the potential to offer more sophisticated mentoring because the mentors’ responses can be automated. With professionally-trained mentors communicating with students through a chat program, the educator might be relieved from addressing domain-specific questions. Additionally, the cost of virtual mentoring is potentially lower than the cost of face-to-face mentoring because one virtual mentor can likely mentor more novices than one face-to-face mentor.

It is unclear whether the constraints of virtual mentoring, namely the possibilities for lost information and miscommunication, outweigh the affordances. Therefore, since there are practical and theoretical reasons to explore virtual mentoring, this study explores whether having mentors communicate with players through a virtual chat program rather than face-to-face changes anything about the players’ experience. To do so, we measured the quantity and quality of the reflection meeting discourse content and level of engagement in two conditions of
the epistemic game, Urban Science, a virtual environment in which players work as interns at a fictional, virtual urban planning firm (Author1 & Author2 2009).

**Quantity and Quality**

In discourse analysis, word counts are widely used to quantify discourse because higher word counts are often correlated with higher quality discourse (Pennebaker et al., 2007). However, word counts are most often paired with qualitative analyses or more rigorous quantitative methods to more fully understand the complexities of the discourse. For example, Schneider et al. (2002) used word counts to compare online and face-to-face focus group participants’ discourse. Their word count comparison showed that online focus group participants tended to contribute fewer words to their discussions than the face-to-face focus group participants. Their qualitative analysis expanded that finding by showing that participants were less likely to explain their opinions or to provide detailed insight into the thinking that led them to their conclusions.

The quality of the mentor and player discourse can also be measured by exploring ways in which particular qualitative characteristics of discourse are representative of professional thinking. Lave and Wenger (1991) argue that communities of people who share a common body of knowledge, a set of skills, a value system, and a set of decision-making processes are communities of practice. Certain types of professional communities of practice, for example, have developed unique ways of doing, knowing, being, caring and warranting. Epistemic frame theory suggests that each profession has a distinct epistemic frame that consists of “the combination –linked and interrelated—of skills, knowledge, identity, skills, and epistemology” (Author2, 2007, p. 160). According to epistemic frame theory (Author2, 2007), skills are the things that people within a profession do, knowledge is the understandings that people in the profession share, identity is the way that members of the profession see themselves, values are the beliefs that members of the profession hold, and epistemology is the warrants that justify actions or claims as legitimate within the profession. Put in more concrete terms, ecologists act like ecologists, identify themselves as ecologists, are interested in ecology, and know about complex, interdependent natural cycles, biotic and abiotic environmental features, and other technical domains. The same is true for other professionals like engineers, computer scientists, mathematicians, and science journalists, but for different ways of thinking and with different epistemic frames.

Central to epistemic frame theory is its explicit focus on the linkages between epistemic frame elements. Skills are always linked to some form of knowledge, values, identity, and epistemology (and each of the other elements are, in turn, associated with all the others); however, they are not always linked to the same ones, or in the same ways. Thus, modeling the structure of the links between epistemic frame elements can be used to measure the quality of discourse in an epistemic game (Author2, 2010).
Impact

One reason games are used in education is because they are engaging to young people (Gee, 2003; 2007, Author2, 2007). However, there has been little research measuring how engagement during game play affects an individual’s personal beliefs or attitudes. Therefore, in this study, engagement was measured using a validated measure developed for use into a text-based narrative world (e.g. a novel) by Green and Brock (2000).

Research on engagement in narratives suggests that the extent to which one becomes engaged, transported or immersed in a narrative influences the narrative’s potential to affect subsequent story-related attitudes and beliefs (Busselle and Bilandzic, 2008). Green and Brock (2000) argue that engagement can be measured by quantifying the extent to which individuals are absorbed into a story or transported into a narrative world.

Green and Brock conceived of transportation as a convergent process, where all mental systems and capacities become focused on events occurring in the narrative (e.g. being lost in a story; Nell, 1988). The first consequence of transportation is that parts of the world of origin become inaccessible. For example, a transported reader may not notice others entering the room. Second, transported readers may experience strong emotions and motivations, even when they know the events in the story are not real (Gerrig, 1993). For example, when transported into narratives with unhappy endings, transported individuals are likely to engage in what Gerrig (1993) termed anomalous replotting: “actively thinking about what could have happened to change an outcome” (p.177).

Green and Brock (2000) write about transportation into a text-based narrative world (e.g. a novel), but they argue that transportation is not limited to the reading of written material. Rather, narrative worlds are broadly defined with respect to modality; the term “reader” may be construed to include listeners, viewers, or any recipient of narrative information. Whether the narrative is fictional or nonfictional, the same processes involved in transportation are theorized to occur. In addition, Bangert-Drowns and Pyke (2001) suggest that electronic educational media such as tutorials, simulations, interactive activities, and websites, though not often thought of as texts, are increasingly a preferred means of information for young people. Thus, Green and Brock’s (2000) principles of transportation may be useful in measuring the impact of a virtual experience like Urban Science on players’ level of engagement.

Methods

This section describes the setting and the activities for both conditions of Urban Science and then discusses the three types of data that were collected, segmented, coded, and analyzed: (1) discourse data from the reflection meetings, (2) players’ intake and exit interview responses and (3) players’ final proposals.
Participants

21 high school aged players (11 females, 10 males) recruited by outreach specialists at the Massachusetts Audubon Society’s Drumlin Farm Wildlife Sanctuary played a 10-hour version of Urban Science as part of a week-long Conservation Leadership Program in August 2010. The education specialists recruited young people who had previously participated in at least one Massachusetts Audubon Society program, though not necessarily a program at Drumlin Farm Wildlife Sanctuary. Thus, players had experience with Massachusetts Audubon Society programming, but they had no prior experience with urban planning.

The two mentors (called planning consultants) in the game were an education researcher (the primary author) and a Drumlin Farm education specialist. Both mentors underwent a one-day training that covered the urban planning profession, the game’s activities, and preferred mentoring strategies. In addition, the mentors met before each session to plan for the day’s activities and after each session to reflect on those activities. The mentors’ main role was leading team meetings and responding to player questions and is described in more detail in the game description section. The mentors were given a script to follow, called the game’s playbook, and they were instructed to keep the conditions as similar as possible.

Intervention

The data for this study were collected from two conditions of Urban Science. In the game, players were assigned to one of two conditions, face-to-face or virtual chat (typed, not video). In each condition, players were assigned to one of three teams representing a specific set of stakeholder (people who care about the site) concerns (e.g. People for Greenspace, Madison Developers’ Consortium, or Northside Neighbors). Each stakeholder team worked with one of the two mentors. There were two adults physically in the room with the players in the chat condition. Players were told that those adults, both education researchers, were in the room to help with technical problems, and that questions dealing with the game should be sent to the virtual mentors. Everything else about the two games was the same (or as close to the same as possible).

Urban Science began with players signing into an office intranet portal where they received instructional emails from an NPC supervisor controlled by their mentor. Players were asked to produce land use plans for a community. To make these plans, players conducted research during a “virtual site visit,” in which they learned about a group of stakeholders’ goals for the site. They conducted preference surveys, in which they worked with their colleagues to more specifically identify their stakeholder group’s goals. To create the preference surveys, players used a geographical information system (GIS) software program called iPlan that allowed them to see projected social and environmental impacts of land use changes. Issues included things like number of jobs and sales, available housing options, and pollution levels. Their stakeholder group provided feedback on the players’ surveys, which allowed the players to triangulate just how much change to the site would please their stakeholder group. Finally, players created a final land
use proposal that attempted to meet the needs of both the stakeholders they researched and the groups of stakeholders that other teams of players studied. In the final proposal, they created a model for a proposed redeveloped site using iPlan and wrote a final report in which they described and justified their recommendations, as well as the limitations and compromises they needed to make. Throughout the game, mentors were available to help the players if they struggled and to guide players’ reflection on their work.

Mentors held reflection meetings where they asked players what they finished doing, what they learned during the last activity, what they thought should happen next, and what additional information would be helpful. The mentors were instructed to listen to the responses before interjecting, and after players responded, the mentor revoiced (Cazden, 2001) and extended the players’ responses to include specific epistemic frame elements pre-determined to be important for that specific point in the game. If the players did not mention the pre-determined epistemic frame elements, the mentor was instructed to fill in the gaps using the playbook script.

Data collection, analysis, and coding

This study examines three sources of data that were collected in both the face-to-face and chat conditions of Urban Science: (1) discourse data from the reflection meetings, (2) players’ intake and exit interview responses and (3) players’ final proposals. In both conditions, the online portal recorded the players’ exit interview responses. In the chat condition, all of the players’ and mentors’ reflection meetings were recorded by the online portal. In the face-to-face condition, the reflection meetings were audio recorded and transcribed. All records were de-identified by replacing references to usernames (names used to sign into the online portal) with pseudonyms, such that the resulting data set contained no identifying information about the participants.

Players were asked six four-point Likert-scale (1=strongly disagree, 4=strongly agree) questions during the exit interview (Table 1) to measure their level of engagement during the game. The questions were adapted from Green and Brock’s (2000) narrative questionnaire to fit the virtual internship environment rather than the literary environment from which they originate. The mean scores for each of the six questions were calculated within each condition, and t-tests were used to compare the responses between conditions.

Table 1 Exit interview questions used to measure engagement. The questions were adapted from Green and Brock’s (2000) narrative questionnaire to fit the virtual internship environment rather than the literary environment from which they originate.

<table>
<thead>
<tr>
<th>Question number</th>
<th>Question text</th>
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<tr>
<td>E1</td>
<td>While I was in the internship, I could easily picture the events in it taking place.</td>
</tr>
<tr>
<td>E2</td>
<td>I could picture myself in the internship.</td>
</tr>
<tr>
<td>E3</td>
<td>I was mentally involved in the internship while it was going on.</td>
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</tbody>
</table>
After finishing the internship, I found it easy to put it out of my mind.

I wanted to learn how the internship would turn out.

I found my mind wandering while doing the internship.

Responses from a matched-pair question in the intake and exit interviews were analyzed to determine whether the players’ interview outcomes were different between conditions. The matched-pair question asked players to consider possible solutions to improving the water quality in a lake or river:

The town of Maple Ridge, MI [Forest Hill, CO] is concerned about high levels of nitrates and carbon tetrachloride in their lakes [rivers]. What could they do to clean up their lakes [rivers] if they care most about reducing the level of nitrates (NO$_3^-$) [carbon tetrachloride (CCl$_4$)]?

The matched-pair interview responses were coded (using the codes described below) and scored on a 0-2 scale, in which a zero indicated an incorrect response, one indicated a partially correct response, and two indicated a correct response.

Players’ final proposals were analyzed to determine whether the players’ final proposals were different between conditions. The final proposals, including the sample final proposal available to all players, were segmented by section and coded using the codes described below.

Mentor and player discourse from four reflection meetings were analyzed to determine whether the discourse was different between conditions. The reflection meetings were segmented by conversational turn and coded using a set of 21 codes developed using the American Planning Association’s (2011) description of what professional planners know, do, and care about and epistemic frame theory as a guide for categorizing professional thinking. A set of representative excerpts were chosen from the full data set, and grounded theory (Strauss & Corbin, 1998) was used to develop a more specific set of qualitative codes representing aspects of urban planning expertise.

While coding the data, the coder read each excerpt separately and applied one code (presence = 1, absence = 0) at a time. The validity of the coding process was checked through an inter-rater reliability analysis in which an educational psychology researcher working in a non-planning domain was trained on the coding scheme and independently coded 150 randomly selected excerpts of the data. Correlation among the codes assigned by both the primary and secondary coders were checked, and all codes had a Cohen’s Kappa greater than 0.6 (Landis & Koch, 1977).

The qualitative analyses uncovered several themes in the reflection meeting discourse data (e.g. discourse about stakeholders’ desires), and an emerging

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1 Text in brackets denotes the matched-pair text.
quantitative technique called Epistemic Network Analysis (ENA) was used to
triangulate the qualitative data and examine how the themes unfolded and whether
or not they unfolded similarly or differently across conditions.

ENA measures relationships among epistemic frame elements within an
epistemic network (Author2 et al., 2009) and was applied to the mentor and player
reflection meeting discourse data and players’ final proposals. Since ENA is an
emerging technique, the variables and equations used in the ENA calculations for
Urban Science are defined here. In ENA, the urban planning epistemic frame is
characterized by individual epistemic frame elements $f_1, \ldots, f_n$. Any participant
discourse $p$ has data, $D^p_t$, which contains evidence that at time $t$, participant $p$ used
one or more elements of the urban planning epistemic frame. As described above,
each segment of coded qualitative data was represented as a vector with ones or
zeroes representing presence or absence, respectively, of each of the 21 codes. To
construct an epistemic network from $D^p_t$, each coded vector was converted
into an adjacency matrix, $A^{p,t}$, for participant $p$ at time $t$ which calculated the frequencies of
coe-occurrence among the epistemic frame elements (1).

$$ (1) \quad A^{p,t}_{i,j} = 1 \text{ if } f_i \text{ and } f_j \text{ are both in } D^p_t $$

The adjacency matrix $A^{p,t}_{i,j}$ was then used to create a cumulative adjacency
matrix, $F^p$. The coded reflection meeting data were aggregated by topic using the
four questions asked during each meeting as the topics. That aggregation resulted in
16 units of analysis for each individual (four questions asked during four meetings).
Thus, the cumulative adjacency matrix for participant $p$, $F^p$ was calculated by
aggregating the adjacency matrices $A^{p,t}$ by reflection meeting question (2).

$$ (2) \quad F^p = \sum A^{p,n} $$

To control for the variation in excerpt length, the cumulative adjacency
matrices were normalized by dividing each value by the square root of the sum of
squares (3).

$$ (3) \quad nF^p = F^p / \sqrt{\sum (F^p)^2} $$

A classical multi-dimensional scaling (MDS) algorithm was then applied to the
reflection meeting and final proposal adjacency matrices in order to identify the
dimensions that captured the most variance in the data. In this paper, the first and
second dimensions (the dimensions that captured the most variance in the data) are
plotted. The plots with the reflection meeting data were created from adjacency
vectors that included both the mentor and player reflection meeting data. The final
proposal plot was created from adjacency vectors from the players’ final proposals
and the sample final proposal.
Results

The results described below examine both the face-to-face and chat conditions of Urban Science and are organized into four sections. The first section explores the mentors’ reflection meeting discourse using qualitative and quantitative techniques. The second section applies the same techniques to the players’ reflection meeting discourse. The third section describes the players’ outcomes in the two conditions. The fourth section discusses the players’ levels of engagement in each condition.

The small size of the samples (2 mentors and 21 players) means that the following analyses are fundamentally qualitative. Where possible, quantitative analyses are used, and results are reported as means with standard errors. In some cases, inferential statistics are also computed; however, as with any small-scale study, the results are not generalizable to other populations. Thus, the purpose of such significance tests is to show that additional observations made under the same conditions would show similar results (Author2 & Serlin, 2004).

Mentors’ structural differences and semantic similarities between conditions

An initial analysis used word counts to examine structural similarities between the face-to-face and chat conditions. The mean word counts were computed for each mentor during each reflection meeting (a total of three data points for four meetings in each condition, for a total of 24 data points). Across all reflection meetings, mentors in the face-to-face condition used significantly more words (mean = 2857, standard deviation (SD) = 755, p < 0.05)\(^2\) during interactions with their teams than mentors in the chat condition (mean = 1244, SD= 327). Further, within each reflection meeting, the mentors also used more words in the face-to-face condition than in the chat condition (see Figure 1).

\(^2\) The paired Mann-Whitney U test was also significant: z = -3.776, p < 0.05.
Fig. 1 Mentors’ reflection meeting mean word counts with standard error. This graph shows that the mean word counts for all of the meetings were greater in the face-to-face condition than in the chat condition.

An examination of the discourse of one mentor, Elise (pseudonym), working with the “People for Greenspace” stakeholder team in both conditions showed that during Reflection Meeting 1, Elise used nearly three times more words in the face-to-face (1284) condition than in the chat condition (433). For example, Table 2 shows that in both conditions, Elise asked players the same question. She used more words in the face-to-face condition (66) than in the chat condition (12); however, although there were more words in the face-to-face condition, the main topic was similar across the two conditions. In the chat condition, she said, “So, with the information that we have, what should we do next?” Similarly, in the face-to-face condition, Elise said: “[I]f you have information about the site, what do we do now as planners? What’s our next step?”

Table 2 Excerpt from Elise’s discourse during Reflection Meeting 1 for the People for Greenspace stakeholder team showing that, when asking players what they should do next (colored orange), she used more words in the face-to-face condition than in the chat condition.

<table>
<thead>
<tr>
<th>Chat (word count = 12)</th>
<th>Face-to-face (word count = 66)</th>
</tr>
</thead>
<tbody>
<tr>
<td>So, with the information that we have, what should we do next?</td>
<td>Well so what does that mean okay, I don’t want you to look at the calendar and just tell me what the calendar says ok. I really want you to think like planners ok. I want you to think about what, if you have information from your stakeholders, if you have information about the site, what do we do now as planners? What’s our next step?</td>
</tr>
</tbody>
</table>

Although the main discourse elements were similar (asking about next steps), Elise provided additional information in the face-to-face condition to contextualize her request: she addressed a player’s concern about the calendar, made explicit references to the players as “planners”, and used the term “stakeholders”. In her face-to-face excerpt, Elise also repeated herself and used features of face-to-face talk, including filler words (Tannen, 1982) such as “well”, “so”, and “okay” which contributed to the higher word count. Thus, there are a number of reasons why the word count was greater in the face-to-face condition than in the chat condition.

3 Of course, standard error bars as presented here should be interpreted with caution, especially with data derived from small samples: even when standard error bars do not overlap, there may be no statistically significant difference. In this example, each bar represents the mean of three points, so significance testing of the individual meetings was not possible.
Mentors’ discourse compared by condition

During Reflection Meeting 1 in both conditions, the mentor of the “People for Greenspace” team, Elise, talked about stakeholders’ desires by asking players if they trusted the stakeholders to know what is best for the site. For example, in the chat condition Elise asked, “Do we trust the stakeholders to know what’s good for the site?” and in the face-to-face condition she similarly asked, “...do you guys trust that the stakeholders know what’s best for the site? Do you trust the stakeholders, like do you think they know what’s best?” Elise’s discourse in the face-to-face condition contained similar content to her discourse in the chat condition, however her face-to-face discourse contained additional filler (Tannen, 1982) words (“like”) and repetition of the same concepts.

During Reflection Meeting 2 in both conditions, Elise talked about generating hypotheses with data or an interactive model by informing the players that “iPlan measures the projected social and environmental impacts of zoning changes” (Table 3). In both conditions, she discussed iPlan’s ability to “test ways of making the site work for the stakeholders without bringing in actual bulldozers” and ended that portion of Reflection Meeting 2 by reminding players in both conditions that the site “is a complex system, which means that changing one parcel impacts more than one indicator.” She also informed players in both conditions that “there may be trade-offs with every change.” As in Reflection 1, Elise’s discourse in the face-to-face condition contained similar content to her discourse in the chat condition, however, her face-to-face discourse contained additional filler (Tannen, 1982) words (“well”, “so”) and verbal acknowledgements of what the players already said or knew: “...but what all of you were saying is...you all recognize that.”

Table 3 Excerpt from the People for Greenspace stakeholder teams’ Reflection Meeting 2 showing (with color coding) that in both conditions, Elise covered similar content.

<table>
<thead>
<tr>
<th>Chat</th>
<th>Face-to-face</th>
</tr>
</thead>
<tbody>
<tr>
<td>because iPlan measures the projected social and environmental impacts of zoning changes, it allows you to test ways of making the site work for the stakeholders without bringing in actual bulldozers.</td>
<td>Because iPlan can measure the projected social and environmental probability changes, it makes you test ways of making the site work for the stakeholders without actually bringing in bulldozers.</td>
</tr>
<tr>
<td>You discovered that one characteristic of the site is that it is a complex system, which means that changing one parcel impacts more than one indicator. There may be trade-offs with every change.</td>
<td>Well you discovered one characteristic of the site, especially, but what all of you were saying is that it’s a complex system…</td>
</tr>
<tr>
<td></td>
<td>That means that changing one parcel impacts more than one indicator and I think that you all recognize that.</td>
</tr>
<tr>
<td></td>
<td>…So there may be trade-offs with every single change.</td>
</tr>
</tbody>
</table>

Since Elise discussed similar content regardless of condition, her discourse showed similar patterns of epistemic frame co-occurrence between conditions. The similar patterns of epistemic frame co-occurrence in both conditions are illustrated by the locations of the mentor points (means) for each condition in Figure 2 where points closer together have more similar patterns of co-occurrence than points
farther apart. For example, Elise’s discourse during Reflection Meeting 1 is located on the far right of the x-axis and her discourse during Reflection Meeting 2 is located high on the y-axis (Figure 2).

![Graph showing mentors' reflection meeting discourse](image)

**Fig. 2** Mentors’ reflection meeting discourse (with means) showing that regardless of the communication mode, the mentors covered similar content during the reflection meetings.

Meeting-by-meeting, t-tests on ENA-generated discourse means for both chat and face-to-face conditions showed no significant differences (Table 4). In other words, the variance between the meetings was larger than the variance between the conditions.

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Dimension</th>
<th>Chat – Mean (N, SD)</th>
<th>Face-to-Face – Mean (N, SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.59 (3, 0.04)</td>
<td>0.49 (3, 0.06)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.03 (3, 0.04)</td>
<td>0.1 (3, 0.05)</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.05 (2, 0.25)</td>
<td>0.16 (2, 0.1)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.44 (2, 0.07)</td>
<td>0.4 (2, 0.03)</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0.39 (3, 0.08)</td>
<td>0.32 (3, 0.55)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.18 (3, 0.14)</td>
<td>0.21 (3, 0.16)</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0.56 (3, 0.08)</td>
<td>0.32 (3, 0.16)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.09 (3, 0.1)</td>
<td>0.02 (3, 0.19)</td>
</tr>
</tbody>
</table>

The mentors’ patterns of co-occurrence of epistemic frame elements were similar during Reflection Meetings 1 and 2, and those similarities can be seen qualitatively (Table 2) in mentor excerpts and quantitatively in the ENA analysis (Figure 1). Meeting-by-meeting, t-tests on ENA-generated discourse means for both chat and face-to-face conditions showed no significant differences. In other words, the variance between the meetings was larger than the variance between the conditions, and regardless of the communication mode, the mentors covered similar content during the reflection meetings.
Players’ structural differences and semantic similarities between conditions

An initial analysis used word counts to examine structural similarities between the face-to-face and chat conditions. The mean word counts were computed for each player during each reflection meeting (a total of 21 data points for four meetings for a total of 84 data points). Across all reflection meetings, players in the face-to-face condition used significantly more words (mean = 1048, SD = 276) to during the reflection meetings than players in the chat condition (mean = 585, SD = 155, p < 0.05). Further, within each reflection meeting, players also used more words in the face-to-face condition than in the chat condition (see Figure 3).

An examination of the discourse of one team, players who worked with the “People for Greenspace” stakeholders, in both conditions showed that during Reflection Meeting 1, players talked twice as much in the face-to-face condition (307 words) than in the chat condition (145). For example, Table 5 shows that in both conditions, players used more words in the face-to-face condition than in the chat condition to discuss learning about the stakeholders’ desires while completing the virtual site visit. They used more words in the face-to-face condition (104) than in the chat condition (40); however, although there were more words in the face-to-face condition, the main discourse elements were similar across the two conditions.

In the chat condition, one player listed the social and environmental issues that the stakeholders cared about by saying, “People care about wetlands (habitats for sandhill cranes), greenspaces, water quality, and reduction of traffic.” Similarly, in the face-to-face condition, one player discussed the social and environmental issues stakeholders cared about by saying that “it seemed like the wetlands and also like the culture and the community was also really important.”

Table 5 Excerpts from individual players’ discourse during Reflection Meeting 1 for the People for Greenspace stakeholder team showing that, when Elise asked the players what they had just finished doing in Reflection Meeting 1, players used more words in the face-to-face condition than in the chat condition to discuss learning about the stakeholders’ desires (colored orange) while completing the virtual site visit.
I finished the virtual site assessment, and am experimenting with iPlan… People care about wetlands (habitats for sandhill cranes), greenspaces, water quality, and reduction of traffic. Character is diverse people, natural beauty and wetlands, local businesses, parks, and community events.

Um, well, I just finished the virtual site visit and did my site assessment and I found that a lot of the stakeholders cared about the wetlands there. They thought that was a very important thing to the Northside, but based on like the descriptions and stuff given as well like not from like the people but like just the overall description it seemed like the wetlands and also like the culture and the community was also really important and I think that yeah. They like they wanted a way to like keep up the culture and stuff without having to hurt the birds.

Although the main discourse elements were similar (talking about stakeholders’ desires), the player’s excerpt from the face-to-face condition was more disjointed and included features of face-to-face talk such as using the words “like”, “um”, and “well”, which contributed to the higher word count.

Players’ discourse compared by condition

During Reflection Meeting 3 in both conditions, players in the “People for Greenspace” team discussed addressing stakeholders’ desires using a model (Table 6). For example, in both conditions, players talked about their experiences using iPlan to address the stakeholders’ desires and specifically mentioned Maven’s (one of the stakeholders) disapproval of their plans. In the chat condition, one player asked “Why Maven was mad?” and in the face-to-face condition a player also struggled with Maven’s feedback and told the team that “Maven called their plans completely unacceptable.”

<table>
<thead>
<tr>
<th>Chat</th>
<th>Face-to-face</th>
</tr>
</thead>
<tbody>
<tr>
<td>I just sent my 2nd map in also I see why Krista still doesn’t like traffic but why is Maven mad we cannot get it lower than 2… I found that CC14 needs to be lower and thus we must lessen M1 and M2 areas.</td>
<td>Like for example, if you heighten up one thing and another thing goes down. So, it’s sort of hard, well, I managed to even out most things, but for some reason, they [stakeholders] weren’t really like happy…Maven called our plans completely unacceptable…</td>
</tr>
</tbody>
</table>

Table 6 Excerpts from the People for Greenspace stakeholder teams’ Reflection Meeting 3 showing (with color coding) that in both conditions, players discussed similar content.

During Reflection Meeting 4 in both conditions, players talked about the practice of reporting data (Table 7). For example, in both conditions, players announced that, “I found that” or “We got a more exact idea” indicating that they had data to report to the team. In the chat condition, one player reported that she learned that “the stakeholders have high demands”. Similarly, in the face-to-face condition, one player reported that the team had a better idea of “what they [stakeholders] wanted”.

<table>
<thead>
<tr>
<th>Chat</th>
<th>Face-to-face</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

Table 7 Excerpts from the People for Greenspace stakeholder teams’ Reflection Meeting 4 showing (with color coding) that in both conditions, players discussed similar content.
I found that the stakeholders have high demands and that to accomplish the goals you must meet all of the concerns equally thus creating a compromise but still giving something to everyone...

Well, we got a more exact idea of what they [stakeholders] wanted so we can know how to replan I guess?...

Though the players’ discourse contained different filler (Tannen, 1982) words (“like”, “so”), regardless of condition, the players’ discourse showed similar patterns of epistemic frame co-occurrence between conditions. The similar patterns of epistemic frame co-occurrence in both conditions are illustrated by the locations of the player points (means) for each condition in Figure 4. For example, the players’ discourse during Reflection Meeting 3 is located to the left of the origin on the x-axis and their discourse during Reflection Meeting 4 is located below the origin on the y-axis (Figure 4).

![Fig. 4 Players’ discourse from reflection data (with means) showing that regardless of the communication mode, the players discussed similar content during the reflection meetings.](image)

Meeting-by-meeting, t-tests on ENA-generated discourse means for both chat and face-to-face conditions showed no significant differences, with one exception (Table 8). The t-test comparing the first dimension of each condition in Reflection Meeting 1 did show a significant difference (p < 0.05). However, the difference between the conditions may be due to the higher number of words mentors in the face-to-face used when leading the meeting. The difference could also be attributed to players in the chat condition becoming familiar with the online meeting style. However, overall, the variance between the meetings was larger than the variance between the conditions.

<p>| Table 8 Means, number of player points in the mean (N) and standard deviations (SD) for each meeting and each condition with the results of paired t-tests. All of the p-values, excluding the comparison of the first dimensions for Reflection Meeting 1 are greater than 0.05, which means that there were no significant differences between the means of the conditions. |</p>
<table>
<thead>
<tr>
<th>Meeting</th>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.13 (10, 0.26)*</td>
<td>-0.12 (10, 0.12)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.17 (10, 0.18)</td>
<td>-0.13 (10, 0.25)</td>
</tr>
</tbody>
</table>
The players’ patterns of co-occurrence of epistemic frame elements were similar during Reflection Meetings 3 and 4, and those similarities can be seen qualitatively in player excerpts (Table 4) and quantitatively in the ENA analysis (Figure 2). Meeting-by-meeting, t-tests on ENA-generated discourse means for both chat and face-to-face conditions showed no significant differences, with one exception. The t-test comparing the first dimension of each condition in Reflection Meeting 1 did show a significant difference (p < 0.05). However, the difference between the conditions may be attributed to players in the chat condition becoming familiar with the online meeting style. However, overall, the variance between the meetings was larger than the variance between the conditions, and regardless of the communication mode, the players covered similar content during the reflection meetings.

While the results above suggest that there was no difference in discourse quality between the face-to-face and chat conditions, the next section examines whether there were differences in the level of player engagement between conditions.

**Player outcomes**

As described in the Methods section, during the intake and exit interviews, players in both conditions answered the following matched-pair question:

The town of Maple Ridge, MI [Forest Hill, CO] is concerned about high levels of nitrates and carbon tetrachloride in their lakes [rivers]. **What could they do to clean up their lakes [rivers] if they care most about reducing the level of nitrates (NO\textsubscript{3}) [carbon tetrachloride (CCl\textsubscript{4})]?**

Players in both conditions significantly increased their scores (0-2 scale) from the intake to the exit interview (chat condition: mean intake = 0.2, mean exit = 1.4, p < 0.05; face-to-face condition: mean intake = 0.27, mean exit = 0.91, p < 0.05). For example, in the face-to-face condition, during the intake interview, one player suggested, “*They could try to clean it out.*” During the exit interview, the same player provided a much more specific, scientifically accurate answer, “*Get rid of big factories in surrounding areas because that lowers the level on CCl\textsubscript{4} and NO\textsubscript{3}.*”

Further, while both conditions significantly increased their scores from the intake to the exit interview, as Figure 5 shows, there was no significant difference between the two conditions in either the intake or the exit interviews (mean intake chat = 0.2, mean intake face-to-face = 0.27, p > 0.05; mean exit chat = 1.4, mean...
exit face-to-face = 0.91, p > 0.05). Thus, the communication mode with the mentors did not affect the players’ learning outcome on this particular matched-pair interview question.

![Graph showing scores for intake and exit interviews](image)

**Fig. 5** Players’ mean scores for the matched-pair interview question. Mean scores for the matched-pair interview question in both conditions (with standard error bars) showing that the communication mode with the mentors did not affect the players’ learning outcomes.

Though the players’ learning outcomes increased from the intake to the exit interview on the matched-pair question described above and there were no differences in learning outcomes between the conditions, the next logical question to ask is “Were the players’ final proposals different between conditions and if so, how?” While the final proposals cannot be used as a proxy for learning since players only completed them at the end of the game, they can be used to examine whether the players in both conditions connected similar epistemic frame elements and thus learned similar content and professional norms during the game.

Each final proposal was qualitatively analyzed to determine if there were differences between the conditions. The qualitative analysis showed that when writing the recommendations section in both conditions, Players 15 and 24 both used and cited sources for their data, justified recommendations, and discussed the tradeoffs and social and environmental impacts of their recommendations (Table 9). For example, Player 15 in the chat condition found that “increasing the number of wetlands improved the number of cranes and character value.” Similarly, Player 24 in the face-to-face condition recommended “Changing some of the unused areas with no roads or houses into wetlands for the Sandhill Cranes to nest.”

**Table 9** Final proposal recommendations section from Player 15 and Player 24 showing the similarities. Terms that appeared in both players’ final proposals are colored according to the following color scheme: wetlands and cranes, manufacturing (M2), water quality (CCl4), sales, housing.
Based on all of the information I collected and my work with iPlan, I recommend the following changes:

**Changing the M2** to C1-R4 increased the character value while increasing the water quality. This also provided an increase in sales to the people.

Converting the housing to recreational land helped provide greenspace while improving the character value.

Increasing the number of wetlands improved the number of cranes and character value.

Based on all of the information I collected and my work with iPlan, I recommend the following changes:

Changing some of the unused areas with no roads or houses into wetlands for the Sandhill Cranes to nest

Adding more retail in place of 1 family homes to help sales and help people have more jobs

Get rid of any Manufacturing so that there is no CCl4 emitted, but adding retail (as said before) to keep jobs up

Add Open space in areas near the wetlands and in parks to increase greenspace.

Keep most of the housing while changing some into retail in order to increase Traffic.

Thus, the qualitative analyses in this section show that players addressed similar content in their final proposals in both conditions. In order to examine if these excerpts are quantitatively different, the following sub-section uses ENA to explore whether the pattern described above extends to the other players and is a fair sample of the properties of the data as a whole.

Players from both conditions addressed similar content in their final proposals and therefore, had similar patterns of epistemic frame co-occurrence in their final proposals. Using ENA as described above, the final proposals were projected into a high-dimensional space created from data from all of the players’ final proposals and the sample final proposal. Similar patterns of epistemic frame co-occurrence in both conditions are illustrated by the locations of the mean player points for each condition in Figure 6. Points closer together in the high-dimensional space have more similar patterns of co-occurrence than points farther apart. The first dimension accounts for 20.33% of the variance and the second dimension accounts for 16.38% of the variance. The means are similar between both conditions along the first dimension (mean chat = -0.1, face-to-face = 0.1, p < 0.05) and the second dimension (mean chat = 0.01, mean face-to-face = -0.02, p < 0.05). Figure 6 also shows that Player 15’s final proposal is located near Player 24’s final proposal suggesting that the qualitative similarity between the two final proposals described above was also captured in similar had similar patterns of epistemic frame co-occurrence. In other words, Figure 6 shows that regardless of the condition, the players covered similar content in their final proposals.
Fig. 6 Players’ final proposals projected into a high-dimensional space. This projection was created from all players’ final proposals showing that the patterns of co-occurrence were similar in the final proposal content between the two conditions. Small points represent individual final proposals while large points are the means for each condition with standard error bars.

The qualitative analysis showed that the points close together in the high-dimensional space were derived from similar qualitative data, and that players in the face-to-face and chat conditions connected similar epistemic frame elements while writing their final proposals. Consequently, these results suggest that mentor communication mode (face-to-face or chat) did not affect the players’ written explanation of professional planning content in the final proposals.

Player engagement

In order to measure engagement in the exit interviews, players were asked six questions adapted from Green and Brock’s (2000) narrative questionnaire. There was no significant difference between the two conditions on these measures of engagement (Figure 7) suggesting that the mentoring condition did not affect players’ levels of engagement.

Fig. 7 Players’ mean scores for the exit interview engagement questions (with standard error bars) showing no significant difference between the two conditions on these measures of engagement.
Conclusions, limitations and implications

This study extends the research on virtual education by showing that regardless of the mentoring condition, players showed no significant differences in either their level of engagement, outcomes, or reflection meeting discourse. Using engagement questions (Green and Brock, 2000), this study showed that players were engaged in Urban Science, which suggests that virtual environments could be no less motivating and engaging to youth than traditional environments. Despite concerns that virtual mentors might be unable to fully communicate with novices, players in the chat condition were as engaged as those with face-to-face mentoring.

Not only were players in both conditions similarly engaged, they derived similar benefits from playing the game. The gains from intake to exit interviews were similar in both conditions, suggesting that having virtual mentors did not adversely affect those players’ learning outcomes. As their responses to a matched-pair interview question showed, players used more scientific language and gave more specific recommendations for addressing an environmental problem after playing the game. In other words, regardless of mentoring condition, Urban Science successfully equipped players with an urban planning epistemic frame. Further, players’ final proposals reflected similar professional thinking in both conditions. In sum, players were engaged, produced professional documents, and learned professional ways of problem solving, whether their mentors were in the room with them or not.

This study identified that mentors, whether face-to-face or virtual, used similar professional discourse to guide players through the game. Their mentoring led players in both conditions to likewise use similar professional discourse and develop similar epistemic frames. In other words, the co-occurrence of epistemic frame elements within the discourse for both the mentors and the players in each reflection meeting followed similar patterns respectively. These results suggest that the key function of the mentors, to communicate professional ways of thinking, was not diminished in the chat condition.

Bierema and Merriam’s (2002) suggest that the richness associated with face-to-face conversation often diminishes when communication goes electronic. However, the mentors in this study were instructed to follow a script while leading reflection meetings. Therefore, the similar efficacy of the mentoring in each condition may seem less surprising. The players’ discourse, however, was similar between conditions without the benefit of scripts to follow, which suggests that if the mentors follow a script while leading reflection meetings, virtual mentoring can be just as effective as face-to-face mentoring at getting players to discuss specific topics, and thus build professional ways of thinking. Further, it is possible that what is lost in the limited communication medium of chat is either peripheral to the professional substance of the conversation or is provided somewhere else in the game. The rich game context, including detailed instructions and feedback from the NPCs, models and templates for professional products in the professional resources (e.g., sample final proposal), and, of course, the experience of interacting with a sophisticated, virtual model of the physical and social environment, all supported the virtual mentoring. Nevertheless, that virtual mentoring can succeed equally as
well as face-to-face mentoring with the same supports suggests that even the human interactions in a mentoring relationship can work virtually.

Since using more words did not impact the quality of the players’ professional discourse during the reflection meetings, the exit interviews outcomes, the quality of their final proposals, or their level of engagement, mentoring via chat is a viable method for mentoring in the context of epistemic games. A bolder interpretation of the results suggests that since mentoring in virtual and face-to-face conditions produced similar effects on players, epistemic mentoring could be automated and still retain the quality of interactions and players’ level of engagement. If the epistemic mentoring is automated, epistemic games like Urban Science could become more widely available to young people giving them the opportunity to help the world “move beyond what we already know in order to break beyond the boundaries of now to a more beautiful fabric of the future.”

The study presented is, of course, limited. First, the small sample size means that any conclusions are limited to what the sample population did in the context of the epistemic game. Thus, the purpose of the significance tests presented in this paper were to show that additional observations made under the same conditions would show similar results (Author2 & Serlin, 2004. Second, while this study showed that the mode of communication used by the mentors did not affect the players’ reflection meeting content or game engagement, this evidence does not support claims about why mentoring is important in epistemic games. Future studies will examine the important role of mentors in epistemic games. Third, though the players were asked a number of questions related to environmental science during the interviews, this paper uses only one near-transfer matched-pair interview question to highlight players’ environmental science learning gains and the similarities of those gains between conditions. Three far-transfer matched-pair interview questions were not included in the analysis because both conditions showed no outcomes gains between the intake and the exit interviews. The lack of far-transfer gains may be attributed to the short time frame (three days) between the interviews and/or the high quality of answers provided by the players during the intake interview. After all, the players’ previous exposure to environmental science concepts through Massachusetts Audubon Society programs may have situated them well to accurately answer the Urban Science intake interview far-transfer questions. Future work will explore formative and summative assessments used to capture the players’ environmental science learning trajectories and outcomes. Future work may also seek to collect longitudinal data regarding players’ environmental behaviors after playing Urban Science. However, though players developed environmental literacy while playing the game, they may not necessarily become environmental stewards exhibiting environmentally-conscious behaviors after 10 hours of game play. Fourth, the goal of this particular study was not to not judge the specific merits of the particular epistemic frame developed: a question which has been examined before (Author1 & Author2, 2009; Author1, 2010), and presumably will and should be the subject of future research. And, as with any experience that requires an Internet connection, access to Urban Science is restricted to places that have computers with Internet connectivity.
Epistemic frame theory and ENA also presents their own set of limitations. Author2 et al. (2009) have asserted that “the evolution of the epistemic network graph depends partly on the specific point in the experience, the conditions the students experience (some situations may be more likely to evoke statements of values, for example, or identities), and the changing nature of the students’ actual epistemic network as it develops through these experiences.” Thus, by focusing solely on the reflection meetings, interviews, and final proposals, this study tells only part of the story. Further research can examine the epistemic frame development at additional time points and under a wider range of conditions. Future work can also use epistemic network analysis to examine the causal connections between a mentor’s discourse and the players’ discourse and epistemic frame development. ENA is a technique under development, and more recent advances in the science of ENA could shed a different light on the topics at hand. Future work will use more sophisticated ENA techniques to perhaps reanalyze this data further. As automated coding is developed, there may be opportunities to conduct comparative studies using this data set.

Despite these limitations, mentors should consider “stop talking and type” since these results suggest that the mentoring condition didn’t affect the players’ reflection meeting discourse or level of engagement. Moreover, the results of this study have the potential to influence the design, implementation, and assessment of virtual environments. This study suggests that learning in a virtual environment like Urban Science is viable and desirable because virtual environments can expand the range of what players can realistically do and thus also the problems they can address, the possible collaborations they can participate in, and the communities they can inhabit. Learning in a virtual environment gives players a chance to see how the world—or at least some piece of it—works under the guidance of a mentor.

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