Crisscrossing Information Spaces with the IdeaMagnets Tool

Bodong Chen, University of Minnesota, chenbd@umn.edu
Yu-Hui Chang, University of Minnesota, chan1173@umn.edu
David Groos, Minneapolis Public Schools, David.Groos@mpls.k12.mn.us

Abstract: Situated in the tradition of Knowledge Building, this study presents the design of IdeaMagnets, a new tool designed bridge Knowledge Forum, a popular knowledge-building environment, with the open web through web annotation. With the IdeaMagnets tool, we conducted a four-week classroom intervention in five science class in an urban high school in the United States. By constructing a qualitative case study, we investigated how students connected public discourse on the *Green New Deal* and their classroom discourse about energy. Findings suggested that with IdeaMagnets students developed a culture of engaging with public sources to advance their knowledge goals. They were mindful of personal, small-group, and collective knowledge goals when annotating public sources, and they incorporated web annotations made by members of the class when improving ideas in Knowledge Forum. The IdeaMagnets tool design and its emphasis on openness have strong implications for the design of future knowledge-building environments.

Introduction

To what extent can we engage youths in building knowledge relevant to public discourse on vital issues such as sustainability and climate change? To what extent can we bring knowledge practices essential for knowledge creation to students' everyday engagement with public discourse? This paper introduces a design research project named *IdeaMagnets* that attempts to explore these two questions. During this project, we designed a technological tool, IdeaMagnets, to connect public discourse on the open web with science inquiry in the classroom. In this paper, we report a case study describing a classroom intervention conducted in five secondary science classes where students studied a science unit on Energy within the context of the *Green New Deal* in the United States. Below, we first review relevant literature grounding the IdeaMagnets project. After introducing the project, we then describe the project's first classroom intervention, report main findings, and discuss implications for future work in related areas.

Background

The IdeaMagnets project builds on Knowledge Building (KB), a community-centric educational approach initiated by Scardamalia and Bereiter (2006). As an integrated system of theory, pedagogy, and technology, KB aims to "refashion education in a fundamental way, so that it becomes a coherent effort to initiate students into a knowledge creating culture" (Scardamalia & Bereiter, 2006, p. 97). Central to KB as an educational approach is its intention to align schools with knowledge-creating organizations (Bereiter & Scardamalia, 2014). With support from technological tools, especially Knowledge Forum (KF), KB involves students to work collectively as a knowledge community to solve authentic problems by continually improving their own ideas (Scardamalia, 2002). More than three decades of research has demonstrated KB's efficacy in promoting domain understanding, multiliteracies, and epistemic fluency (Chen & Hong, 2016).

To facilitate authentic knowledge-creating practices, technological designs for KB need to support three key areas: (a) Empower learners to take greater collective responsibility in knowledge advancement; (b) Enable ideas to have trajectories of growth independent of human minds; and (c) Facilitate key epistemic practices among learners, such as evidence-based reasoning and metacognitive dialogues (Chen & Hong, 2016). Recent advances in the community reflect efforts made in these areas. For instance, the Idea Thread Mapper tool engages students in collective reflection on their KB discourse so they can co-organize their journey of idea improvement (Zhang et al., 2018). The Promising Ideas tool asks students to take the responsibility of finding "promising" ideas in their community so that they could invest limited resources in promising directions (Chen, Scardamalia, & Bereiter, 2015). To assess students' epistemic agency and shared responsibility, new analytic tools are created and applied to KB discourse data (Ma et al., 2016; Oshima et al. 2012).

However, current KB environments tend to operate as "walled gardens." To deeply integrate education into societal knowledge production, KB can seek to forge a deeper connection between classroom discourse with the public sphere. On a societal level, youths are already making contributions to dialogues about issues such as climate justice. Educators need to find ways to engage school learning with these societal issues so that the society can learn from youth voices and also position youths as creators of solutions to existential problems. Recent

paradigms of learning have demonstrated the promise of harnessing connectedness to nurture youth participation (Ito et al., 2013; Taylor & Hall, 2013). To realize KB's vision of aligning classroom learning with knowledge creation, new designs are needed to tap into new modes of connectedness, participation, and expression. Thus, we propose a high-level conjecture (Sandoval, 2014): *By bringing essential KB practices (e.g., theory building discourse) to youth engagement with public discourse we can make knowledge building more pervasive and achievable among youths.*

The IdeaMagnets project

To test the high-level conjecture, the IdeaMagnets project attempts to extend KB discourse carried out in Knowledge Forum (KF) into broader cyberspaces by incorporating web annotation technologies. This project, contextualized within high school science, is motivated by the fact that youths make frequent use of web and social media content. To support idea development in KF, and across the web, the IdeaMagnets project attempts to create a knowledge infrastructure that couples a private KF space with the open web space. Ideas are "pulled" from various web spaces to form larger knowledge structures to give birth to newer and bigger ideas; hence the metaphor of "idea magnets." By doing so, IdeaMagnets advances toward the design intention of integrating classroom discourse with public discourse.

To achieve the design goal, the project adopted design-based research (Collins, Joseph, & Bielaczyc, 2004) and participatory design (DiSalvo, Yip, Bonsignore, & DiSalvo, 2017) as the guiding approaches. Year 1 of the project centered on iterative cycles of design workshops and software development in which teachers, researchers, and engineers teamed up to refine the technology. The central focus in this phase was to embody high-level conjectures in tools (Sandoval, 2014). In particular, we aimed to bridge Hypothes.is—an open-source web annotation tool—with KF so that students could easily capture ideas on the web and then import ideas into their KF discourse. Work in Year 1 yielded an IdeaMagnets tool design that included two key components:

(1) *A collaborative web annotation system based on Hypothes.is.* Using a custom setup of Hypothes.is, a student can annotate any public web document with reflective texts, add tags, and contribute annotations to their private/protected community (see Figure 1).

(2) *IdeaMagnets as a new KF feature that queries and imports Hypothes.is annotations.* While Hypothes.is supports threaded discussions, KF provides unique affordances for continual idea development. By adding IdeaMagnets as a new tool in KF, students can have direct access to their community's annotations within KF; they can index, filter, and search web annotations directly in KF. They can also directly drag an annotation into KF to create a *magnet-note* with its unique icon  (see Figure 2).

In Year 2 of the IdeaMagnets project, we co-designed a classroom intervention with one high school science teacher and piloted the tool in five science classes taught by this teacher. The study reported in this paper aimed to understand how students used IdeaMagnets when bridging classroom discourse in KF and public discourse on the broader web. The following research questions were posed to guide the study:

1. In what ways did the use of web annotation facilitate students' sense-making of public discourse?
2. In what ways did the use of IdeaMagnets encourage students to connect public discourse with their classroom discourse?

Methods

Context and participants

The research context was an urban public high school in the midwest United States. With the designed IdeaMagnets tool, we conducted a four-week classroom intervention in five ninth grade science classes taught by a same teacher (n = 97; numbers of participating students in these classes were 14, 16, 22, 25, 20).

Prior to adopting IdeaMagnets, this science teacher had been using KF in his teaching for more than five years. Participating students (in their first high-school year) had been exposed to KB and KF for two quarters. However, it was the first time for the teacher and his students to use Hypothes.is and IdeaMagnets. To develop sufficient technical knowledge of Hypothes.is, students were asked to add Hypothes.is onto the browser and were engaged in a few in-class annotation activities such as annotating their school website. By the time of this study, students had developed some technical knowledge about using Hypothes.is to annotate the web.

Pedagogical design

During the study, the classes were working on a curriculum unit about energy and energy sources. With the "Green New Deal" (GND) trending in the news, the science teacher situated students' work within public discourse around GND. Following the KB pedagogy, students were asked to identify *authentic problems* GND alludes to

and develop their *real ideas* to address these problems. To meet the curriculum objectives, students were asked to complete an energy project to demonstrate their understanding of energy, the carbon cycle, and climate change.

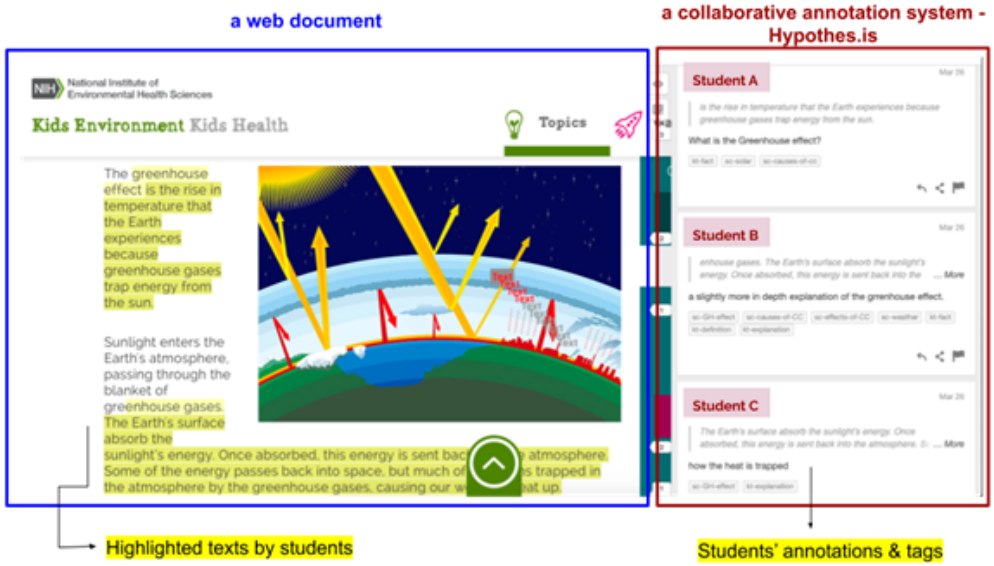

Figure 1. A collaborative web annotation system based on Hypothes.is. A student can highlight a piece of text in a web document (*left*) and create an annotation (and a conversation) about the highlighted text *(right*).

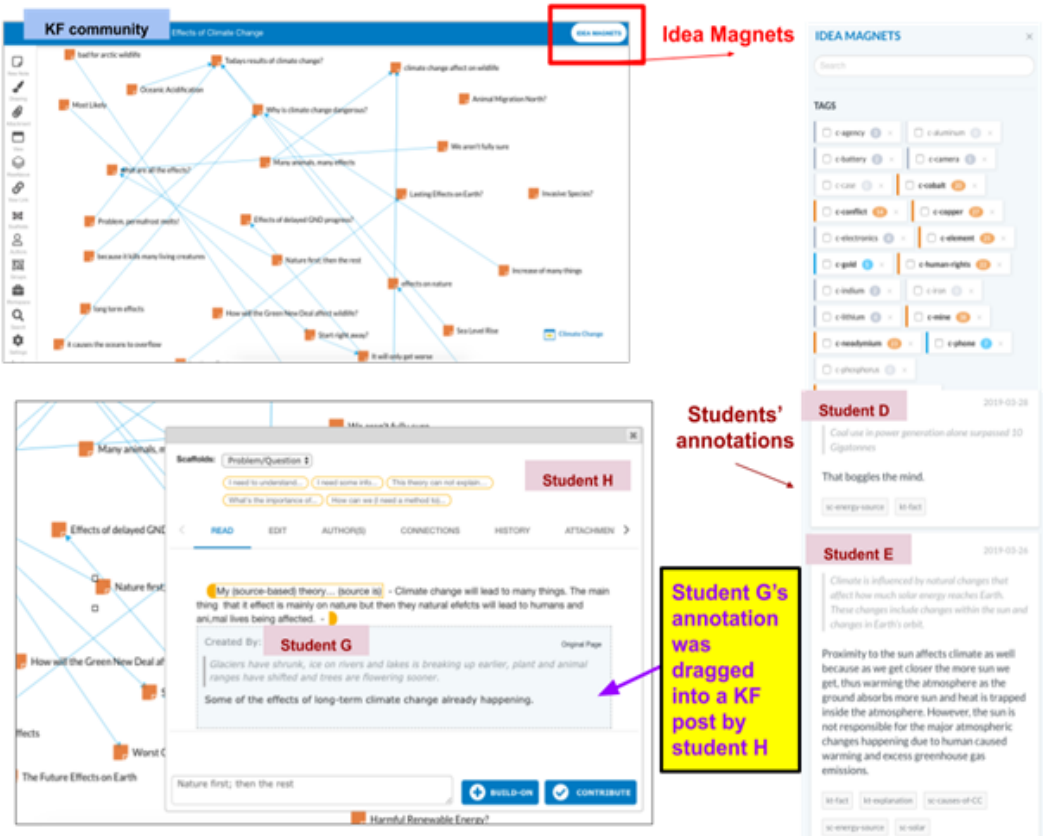

Figure 2. In a Knowledge Forum (KF) view (*upper-left*), Hypothes.is annotations from the community are aggregated in the IdeaMagnets sidebar (*right*), where students can filter annotations by tags or search (*upper-right*). An annotation of interest can be dragged into a KF note for further discussion (*lower-left*).

The teacher-researcher team came up with a pedagogical design emphasizing four KB principles (Scardamalia, 2002): (a) Community knowledge—the class as a community developed collective knowledge

about problems related to GND, and they developed a system to index and use their community knowledge; (b) Improvable ideas—the class identified research problems within groups, crafted research questions in KF, and generated new ideas and improved them based on evidence; (c) Constructive uses of public sources—students used Hypothes.is to annotate and tag relevant articles on the open web to help them address knowledge problems; and (d) Knowledge building discourse—students had ongoing discussions across multiple weeks, such as using Talkwall (Smørdal & Rasmussen, 2019) in class to identify research problems, collectively defining tags for information seeking, using IdeaMagnets to pull ideas from web annotations, and deepening group discussion on KF. Detailed classroom activities designed to support these principles are presented in Table 1. The researchers collaborated with the teacher to identify public materials for students to read. The science teacher had students discuss the purpose of making annotations and invited students to discuss ways to improve their use of tags. By doing so, he gradually established a classroom norm in which students could use Hypothes.is to create annotations with meaningful tags. They generated two types of tags—*knowledge type* tags (e.g., fact, example) and *science concept* tags (e.g., "energy," "agriculture")—to index community ideas about climate change.

Table 1: An overview of the classroom activities in this study.

Weeks	Goals	Activities	Digital learning environments
Week 1	Collectively generate research problems	Read news articles about the GND, defined tags that mapped onto research problems	Twitter (searching tags), Google Form (collecting questions), Talkwall (organizing problems, questions, and tags)
Week 2	Form interest groups and formalize group problems	Formed three project groups: (1) Causes of Climate Change, (2) Goal of 100% Renewable Energy, (3) Effects of Climate Change	Knowledge Forum (posting group questions)
Week 3	Problem-centered engagement with public sources	Read and annotated additional web articles with proper tags.	Hypothes.is (annotating and tagging)
Week 4	Engage in evidentiary reasoning using web annotations	Continued to improve community ideas based on evidence introduced via web annotations	IdeaMagnets (filtering annotations), Knowledge Forum (improving ideas)

Data collection and analysis

To investigate how students engaged with public discourse on the web and how they built knowledge on KF, we relied on semi-structured group interviews with students as the primary data source and used fieldnotes and system logs as two secondary data sources. Based on student logs in digital systems (i.e., KF and Hypothes.is), we purposefully sampled two groups of students to share retrospective accounts of their learning experiences during this study. The first group (n = 15) included students who had actively used all three tools (KF, Hypothes.is, and IdeaMagnets) during the study. The other group (n = 15) included students who used these tools less actively. For each group interview, we pulled a group of three students from class and talked with them for 10-15 minutes about their reflection on their experiences. All the interviews were transcribed anonymously. We also drew on system logs to generate descriptive statistics of user behaviors and triangulate findings across all data sources.

The researcher conducted content analysis through two coding cycles: process coding and pattern coding (Saldaña, 2016). Each coding cycle generated researcher memos and open codes that captured learners' perspectives on why and how KF, Hypothes.is, and IdeaMagnets supported their learning (see Table 2). All the opening codes and memos were processed through axial coding through which the researcher merged related codes to form common themes.

Results

Table 2 shows results of the content analysis and provide an overview of how students actually used Hypothes.is and IdeaMagnets to approach public discourse, according to their responses. Overall, we found that in addition to technical features, they also mentioned various knowledge building affordances offered by these tools. Based on the coding results, Figure 3 further illustrates patterns of learners' sense-making processes as they connect public and classroom discourses. In this section, we first examine students' actual use of Hypothes.is and IdeaMagnets and then present patterns of their discourse processes.

In what ways did web annotation facilitate student sense-making of public discourse?

Actual usage and perceived usefulness of web annotation

During the Energy unit, 57 students (59%) used Hypothes.is to engage with public discourse on topics such as the causes of climate change and alternative energy sources. We found not all students could complete the in-class annotation activity in time, leaving some annotations being created without tags. In general, students mostly appreciated using web annotation to collect information and support deeper engagement with online materials. One student described:

> Using Hypothes.is has helped me think about articles more, because I know it's easy to just read them and then just forget about the stuff that you read. But when you have to make annotations and really think about the stuff that you're highlighting and making annotations about, it's a lot easier to remember information because you're like, "oh yeah I remember that [because] I made an annotation and I talked a bit about that." (Student L, Class A)

Table 2. Initial open codes of students' approaches to using the digital environment

Initial categories of open codes	Example subcategories
Technical features	● Information gathering, organizing, retrieval, note-taking (HY) ● Tagging: technical knowledge about how tags work (HY) ● Being able to see others' annotations (HY) (IM) ● Searching specific tags (IM)
Knowledge building affordances	● Using evidence in each other's annotations (HY) (IM) ● Collaborating with peers, more than knowing (IM) ● Connecting, comparing, and synthesizing ideas (IM)
Difficulties and suggestions	● Suggesting a new feature (HY) ● Suggesting to improve the search feature (IM) ● Difficulty due to wrong or unorganized tags ● More helpful if more people get involved

Note: HY—Hypothes.is; IM—IdeaMagnets.

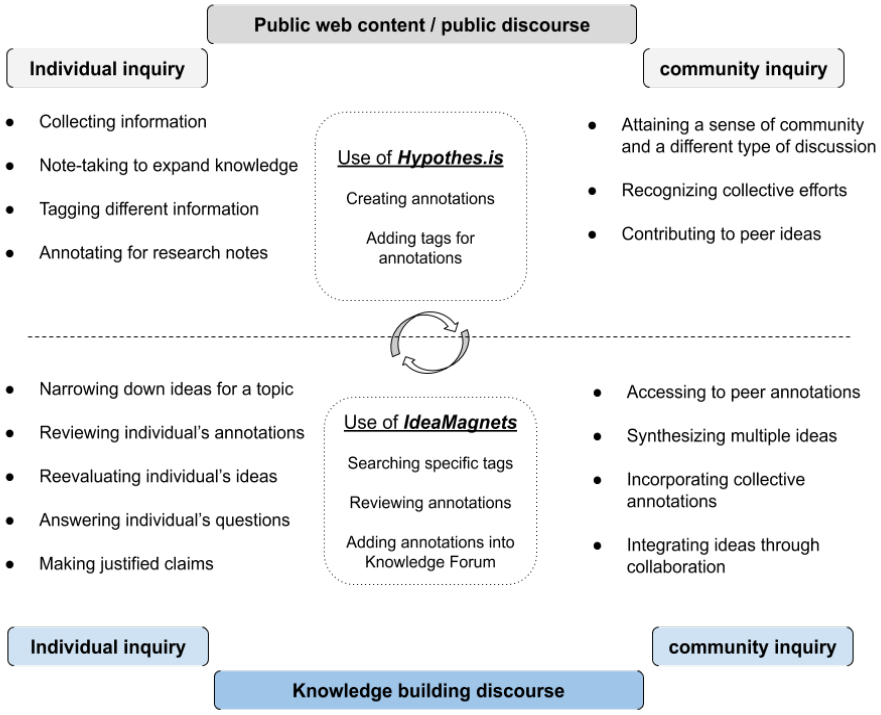

Figure 3. Learners' sense-making processes involving public and classroom discourse.

Discourse patterns involving the use of web annotation

In addition to taking advantage of the surface-level features offered by Hypothes.is (e.g., taking notes), student interviews revealed their deeper thinking about using web annotation to facilitate knowledge building at both the individual and community levels. As illustrated in Figure 3, some students created annotations on top of public discourse to expand individual knowledge. In this regard, they mentioned that by using different and more diverse tags they could increase searchability of annotations and hereby benefit their knowledge building efforts. For example, one student (Student A, Class E) suggested adding more relevant tags to her own annotations to increase the likelihood of sharing a tag with annotations made by her classmates. During this study, she was inclined to make a list of tags individually and combine them with those from the community afterwards so that "when people need to search they can have everybody's tags." Apparently, this student had come up with some unique strategies to connect personal annotations with peer contributions in the community.

Meanwhile, some other students recognized the power of using Hypothes.is as the community's knowledge base that is indexed by tags and connected with the public web. For example, one student described that "it [was] really helpful to have so many annotations," because she would not have so many resources and "everyone's work to build [on]" (Student P, Class D). Notably, students demonstrated a sense of community when annotating public sources and viewed individual annotation as a way to contribute to peer and collective ideas.

In what ways did IdeaMagnets encourage students to connect public discourse with their classroom discourse?

Actual usage and perceived usefulness of IdeaMagnets

All students used the IdeaMagnets tool in Knowledge Forum to review annotations or filter them using tags. In the Week 4 of this study specifically, 33 students (34%) used IdeaMagnets to import web annotations into their KF posts (i.e., creating *magnet-notes*). Whether the use of IdeaMagnets was to review/search annotations or to add annotation in a magnet-note, students shared they could benefit from this process when they were collectively tackling the same topic. IdeaMagnets helped them grapple with a more diverse pool of ideas grounded in public discourse, and some students developed sophisticated tag-based searching strategies to filter this pool of community annotations. For example:

> Z: Well, a lot of people were using IdeaMagnets, and a lot of people were studying copper, like me. So I was able to just go in there and find stuff that was relevant to what I was learning.
> M: It makes it easier to find stuff…
> Z: It's good to switch out which tags you're searching with. So if you're trying to find a specific source, then if you only click copper and human resource, or whatever, then you gotta switch up which ones you're in. (Student Z & M, Class E)

Discourse patterns involving the use of IdeaMagnets

In addition to reviewing or importing web annotations into Knowledge Forum discourse, students were excited about being able to integrate ideas and making justified claims in both individual and community inquiry (see Figure 3). Whether students were using a peer's annotation to tackle a research problem, they tended to synthesize multiple ideas and integrate peer ideas that stemmed from public discourse. The idea sensemaking and integration process helped the students "keep the conversation going" by continually integrating ideas connected with the public sphere (see Figure 3). For example, in Figure 4, one student (Student M, Class C) created a *magnet-note* to build on a group question "why is it called GH [greenhouse] gas" by adding another student (Student I, Class C)'s annotation into the post. In this example, Student M also continued to add her comments to summarize the main ideas from a public source. Interestingly, no matter whether students used IdeaMagnets, they acknowledged that their groups used IdeaMagnets to help answer their group questions. For instance:

> T: Well especially with IdeaMagnets, if you're making an annotation or, [magnet-note], writing thing, it was helpful to look at what other people had found about that and opposing ideas too, so you can look at what they're doing and then put that in and it would make a better answer for you.
> L: And if I wanted to learn about somebody else's topic, or if I wanted to contribute to someone else's thing, if it connected to mine I could use my own annotations but also other people's annotations that I didn't personally study. (Student T & L, Class D)

Some students also mentioned that the experience of harnessing a cluster of community ideas captured from public discourse encouraged them to continue reading web materials to add more information through tagged annotations.

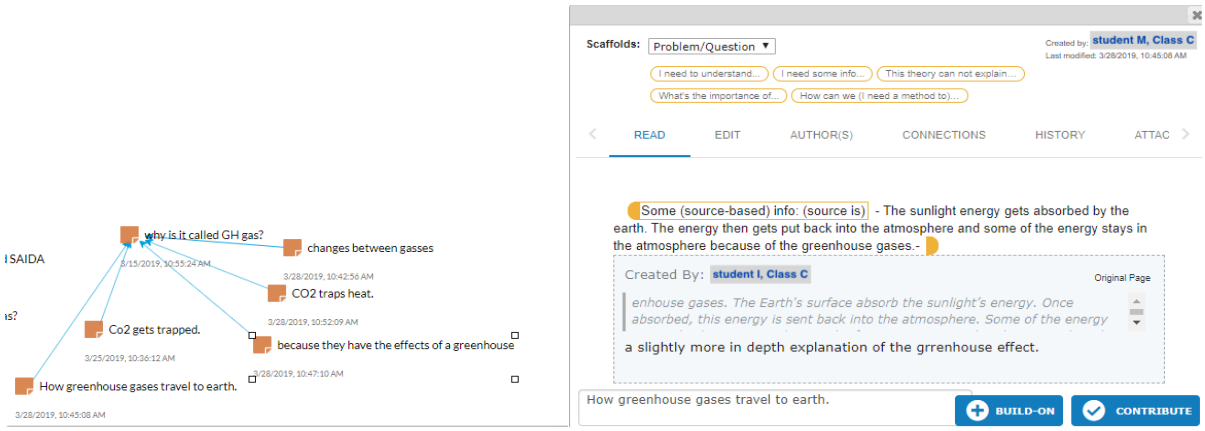

Figure 4. An example illustrated how students keep the conversation going by creating a *magnet-note* (*top*) to address a group question of "why is it called GH gas" (*bottom*).

Discussion and implications

This paper reports preliminary findings from the IdeaMagnets project that attempts to use web annotation to connect classroom discourse with public discourse. Our findings provided a snapshot of ways in which students navigated their discourse spaces and constructed understanding based on collective efforts of making sense of public materials. Discourse patterns revealed from our research data portraited two key features of the discourse supported by the IdeaMagnets tool:

- *A learning culture of annotation.* Many students found web annotation not only useful for information collection and note taking, but also for deeper engagement and easier recall. When working on their energy projects situated in the Green New Deal, they purposefully annotated information to address their research problems, as well as to index information from public discourse for easier information retrieval during classroom dialogues.
- *Purposeful and constructive use of sources.* Students highlighted that with the assistance of Hypothes.is and IdeaMagnets, they were able to introduce evidence to advance their understanding of particular knowledge problems. They recognized IdeaMagnets helped them make use of their own and each other's ideas through tag filters. As a result, they could more easily compare or connect different ideas to address various research problems.

Overall, findings from this study showed great promise of engaging students to purposefully annotate public discourse. Technologically, the IdeaMagnets tool design strengthens knowledge-building environments by extending ideas created in one context (in public discourse) into another context (e.g., KF discussions); in this case, ideas "become objects of discourse in their own right" (Scardamalia & Bereiter, 2003, p. 5). For learners, discourse processes facilitated by the tool and pedagogical design helped them navigate complex web spaces, anticipate future use of ideas when annotating web materials, and draw on each other's contributions to solve ill-defined knowledge problems. Collaboration in this context is more emergent and opportunistic, while learners are responsible for performing important epistemic tasks such as meaningfully tagging annotations, intentionally filtering annotations, and integrating multiple ideas to address knowledge problems.

The reported descriptive case study is only the beginning of an attempt to integrate knowledge-building discourse in classrooms with public discourse and societal knowledge creation. In the immediate future, we will closely examine discourse content generated from this intervention to uncover patterns of students' knowledge practices. Using the lens of epistemic cultures (Knorr Cetina, 1999), we will focus on ways in which learners create and warrant knowledge with knowledge objects from public discourse. We will also seek to build stronger knowledge-building scaffolds in web annotation tools and design and test new pedagogical strategies.

References

Bereiter, C. (2002). Liberal education in a knowledge society. *Liberal Education in a Knowledge Society*, (2006), 11–33. Chicago: Open court.

Bereiter, C., & Scardamalia, M. (2014). Knowledge building and knowledge creation: One concept, two hills to climb. In S. C. Tan, H.-J. So, & J. Yeo (Eds.), *Knowledge creation in education* (pp. 35–52). Springer.

Chen, B., & Hong, H.-Y. (2016). Schools as knowledge-building organizations: Thirty years of design research. *Educational Psychologist, 51*(2), 266–288. https://doi.org/10.1080/00461520.2016.1175306

Chen, B., Scardamalia, M., & Bereiter, C. (2015). Advancing knowledge building discourse through judgments of promising ideas. *International Journal of Computer-Supported Collaborative Learning*, *10*(4), 345–366. https://doi.org/10.1007/s11412-015-9225-z

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *Journal of the Learning Sciences, 13*(1), 15–42. https://doi.org/10.1207/s15327809jls1301_2

DiSalvo, B., Yip, J., Bonsignore, E., & DiSalvo, C. (Eds.). (2017). *Participatory Design for Learning*. New York: Routledge.

Ito, M., Gutierrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., Schor, J., Sefton-Green, J., Watkins, S.C. (2013). *Connected learning: An agenda for research and design*. Irvine, CA: Digital Media and Learning Research Hub.

Knorr Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Harvard University Press.

Ma, L., Matsuzawa, Y., & Scardamalia, M. (2016). Rotating leadership and collective responsibility in a grade 4 Knowledge Building classroom. *International Journal of Organisational Design and Engineering, 4*(1-2), 54-84.

Oshima, J., Oshima, R., & Matsuzawa, Y. (2012). Knowledge Building Discourse Explorer: A social network analysis application for knowledge building discourse. *Educational Technology Research and Development: ETR & D*, *60*(5), 903–921. https://doi.org/10.1007/s11423-012-9265-2

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67–98). Chicago, IL: Open Court.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building environments: Extending the limits of the possible in education and knowledge work. In A. DiStefano, K.E. Rudestam, & R. Silverman (Eds.), *Encyclopedia of distributed learning* (pp. 269-272). Thousand Oaks, CA: Sage.

Saldaña, J. (2016). *The coding manual for qualitative researchers: 3rd edition*. Thousand Oaks, CA: Sage.

Sandoval, W. (2014). Conjecture Mapping: An approach to systematic educational design research. *Journal of the Learning Sciences*, *23*(1), 18–36.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building environments: Extending the limits of the possible in education and knowledge work. In A. DiStefano, K. E. Rudestam, & R. Silverman (Eds.), *Encyclopedia of distributed learning* (pp. 269–272). Thousand Oaks, CA: Sage Publications.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 97–115). Cambridge University Press.

Scardamalia, M., & Bereiter, C. (2014). Knowledge building and knowledge creation: Theory, pedagogy, and technology. In R. K. Sawyer (Ed.), *Cambridge Handbook of the learning sciences* (2nd ed., pp. 397–417). New York, NY, USA: Cambridge University Press.

Smørdal, O., & Rasmussen, I. (2019). Bridging concepts as intermediary knowledge in design: Productive dialogues and the talkwall microblogging tool. *A Wide Lens: Combining Embodied, Enactive, Extended, and Embedded Learning in Collaborative Settings, 13th International Conference on Computer Supported Collaborative Learning (CSCL) 2019, Volume 1*, 993–996.

Taylor, K. H., & Hall, R. (2013). Counter-mapping the neighborhood on bicycles: Mobilizing youth to reimagine the city. *Technology, Knowledge and Learning, 18*(1-2), 65-93.

Zhang, J., Tao, D., Chen, M. H., Sun, Y., Judson, D., & Naqvi, S. (2018). Co-organizing the collective journey of inquiry with idea thread mapper. *Journal of the Learning Sciences, 27*(3), 390-430.

Acknowledgments

This project was funded by the NSF CRII/Cyberlearning program (Award # 1657009).