

## Promoting Collaborative Productive Epistemic Discourse for Disagreement Resolution among Multiple Documents: How Epistemic Scaffolds and Epistemic Scripts in CSCL Worked

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**Abstract:** We describe and investigate a web-based CSCL system called EDDiE to help students analyze multiple conflicting information through collaborative interactions. The application allows students to organize a visual representation to compare and contrast information from multiple conflicting documents in order to resolve disagreements among the documents. The system embeds epistemic scaffolds to guide students' reasoning as they resolve disagreements. Based on the Grasp of Evidence framework, the application helps students collaboratively analyze and compare claims, sources, and evidence across multiple documents. Students thereby deeply discuss reasons for disagreements, seek to resolve the disagreements, and develop their own reasonable conclusion. A preliminary evaluation in a university class (with selected results reported here) showed that the designed epistemic scaffolds and epistemic script elicited productive discussion to justify students' decisions.

### Introduction

Citizens in the 21st century access a wide range of digital information to deal with issues that matter to them in their daily lives, such as which diets or medical treatments are safe and effective. However, citizens also find it challenging to get reasonable ideas or conclusions due to the profusely conflicting information they encounter—from unreliable as well as reliable sources (Kienhues, et al., 2017). An essential competence for reasoning about digital information is the ability to successfully resolve these conflicts and disagreements (Chinn et al., 2020). Thus, recent scholarship has made increasing efforts to help people deal with disagreements among multiple conflicting documents (Thomm et al., 2017; Barzilai et al., 2020).

Research on multiple documents comprehension has emphasized the importance of learning to evaluate and integrate information from varied accounts (Barzilai et al., 2018). Effective integration involves both identifying the disagreements that exist (Thomm et al., 2017) and coming up with ways to resolve these disagreements successfully (Allchin, 2011). The goal of the project is to design and evaluate a web-based CSCL system that fosters productive collaborative epistemic discourse regarding how to identify and attempt to resolve disagreements among multiple documents. In this paper, we describe the system and present selected results of a study that investigated how fostered students' collaborative efforts to identify and resolve disagreements among documents on a scientific issue.

### Designed epistemic scaffolds and epistemic scripts on EDDiE system

We have developed a CSCL system, referred to as EDDiE (Electronic Documents Disagreements Evaluation), which is a multi-user, interactive web application. Users collaboratively read a set of multiple documents and create a visual graphic organizer (*analysis tableau*) to synthesize information and analyze disagreements (see Figure 1 for an example). The analysis tableau is designed to serve as an epistemic script (Weinberger et al., 2005) that guides the thinking processes to consider alternative disagreement resolution strategies and reach a sound resolution or conclusion. Students can highlight any parts of any multiple documents in the left pane and drag and drop them to represent critical epistemic aspects of the documents, including: what the main claims, evidence, and sources are, their evaluation of source credibility, their evaluation of the knowledgeable sources (e.g., the experts cited in the documents), and evidence from each document. Students evaluate the quality and strength of each of these components in the documents using various graphic symbols with serve as epistemic scaffolds that support reasoning; these are displayed in Figure 1 (Sandoval & Reiser, 2004; Tang, 2020).

EDDiE is grounded theoretically in the Grasp of Evidence (GoE) framework (Duncan et al., 2018). Table 1 explains how the GoE framework provides the grounding for many epistemic scaffolds. One additional scaffold is the provision of *disagreement reasoning tags*, which show possible disagreement reasons among multiple conflicting information. These tags can be generated by students themselves (in group or class discussions) or preset by

instructors. Students select tags to identify reasons for disagreement among the documents (see Figure 1, a pop-up menu appeared around the row of “Document 5”).

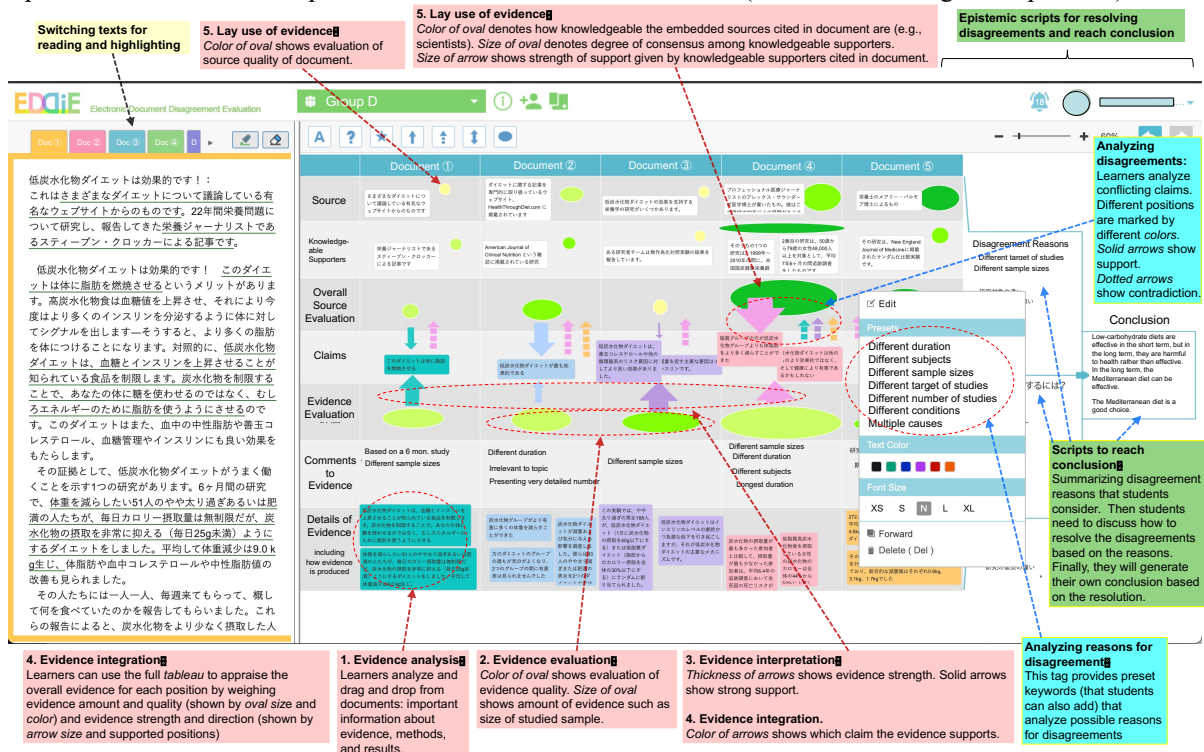
**Table 1**

Epistemic scaffolds based on Grasp of Evidence Framework and expected students’ activities.

GoE Dimensions	Definition	Epistemic scaffolds within the system and expected activities
<b>1. Evidence Analysis</b>	Breaking down the evidence into its component parts and comprehend how the parts fit together.	Students collaboratively extract, analyze and record important elements of evidence (e.g., sample size, critical comparisons, results) in the <i>analysis tableau</i> by dragging and dropping sentences in each document.
<b>2. Evidence Evaluation</b>	Scrutinizing the methodological quality of the studies that produce evidence.	Students evaluate the quality of evidence via the <i>color of evidence circles</i> . High quality evidence is colored dense green; poor evidence is colored yellow.
<b>3. Evidence Interpretation</b>	Examining how strongly evidence supports or contradicts different explanations.	<i>Arrow thickness</i> between evidence and claims reflects evidence strength. Thick arrows mean strong evidence for the claim. Thin arrows mean weak evidence. <i>Dotted arrows</i> mark disagreements. Colored dotted arrows mean counter-evidence to the same-colored claims.
<b>4. Evidence Integration</b>	Considering how large, diverse, and often conflicting bodies of evidence relate to competing explanations	<i>The size and shape of evidence circles</i> mark evidence quantity. <i>The color of arrows</i> denotes which claim the evidence supports. Students easily recognize consistencies or inconsistencies of evidence across the documents and each evidence quality.
<b>5. Lay use of Evidence</b>	Examining evidence in light of laypeople’s bounded knowledge and limited expertise; appraising source trustworthiness, expert consensus, etc.	The knowledgeable supporters circles and arrows ( <i>size and color of circles, color and width of arrows</i> ) denote lay evaluation of quality and consensus of experts that support the document’s claims.

**Figure 1**

Epistemic scaffolds and scripts embedded in the interface of EDDiE (translated into English as possible)



**Switching texts for reading and highlighting**

**5. Lay use of evidence**  
Color of oval shows evaluation of source quality of document.  
Size of oval denotes degree of consensus among knowledgeable supporters.  
Size of arrow shows strength of support given by knowledgeable supporters cited in document.

**Epistemic scripts for resolving disagreements and reach conclusion**

**Analyzing disagreements:** Learners analyze conflicting claims. Different positions are marked by different colors. Solid arrows show support. Dotted arrows show contradiction.

**Conclusion**  
Low-carbohydrate diets are effective in the short term, but in the long term, they are harmful to health rather than effective. In the long term, the Mediterranean diet can be effective.  
The Mediterranean diet is a good choice.

**Scripts to reach conclusion**  
Summarizing disagreement reasons that students consider. Then students need to discuss how to resolve the disagreements based on the reasons. Finally, they will generate their own conclusion based on the resolution.

**Analyzing reasons for disagreement**  
This tag provides preset keywords (that students can also add) that analyze possible reasons for disagreements

**4. Evidence integration**  
Learners can use the full *tableau* to appraise the overall evidence for each position by weighing evidence amount and quality (shown by oval size and color) and evidence strength and direction (shown by arrow size and supported positions)

**1. Evidence analysis**  
Learners analyze and drag and drop from documents: important information about evidence, methods, and results.

**2. Evidence evaluation**  
Color of oval shows evaluation of evidence quality. Size of oval shows amount of evidence such as size of studied sample.

**3. Evidence interpretation**  
Thickness of arrows shows evidence strength. Solid arrows show strong support.

**4. Evidence integration.**  
Color of arrows shows which claim the evidence supports.

## A Case Study

In a case study to investigate how students learn with EDDiE, we engaged students in a multiple document comprehension task in an undergraduate class at a private university in Tokyo. Participants were 29

undergraduates studying informatics as their major, divided into seven groups of four or five. One student in each group had been previously trained to facilitate the group exercise. Each group was provided different five documents regarding diets on EDDiE and was asked to reach their sound conclusion on the best ways of dieting.

Here we present one brief case illustrating how the epistemic scaffolds worked to promote evaluative discussions of evidence across the multiple documents. Case 1 shows discourse from a group that was actively referring to the disagreement reasoning tags (3 of 7 groups actively used the preset tags). In the transcript of the discussions, references to the disagreement reasoning tags are shown in **bold**. *Italicized bold* text refers to a student-generated reason for disagreements that was not provided as a preset tag.

**Table 2**

Excerpts from discussions in an integration phase with/without referring to the disagreement reasoning tags

Case 1 (B, C, & D: student participants)	
B: As for the Mediterranean diet, it's <b>a different focus of research</b> , maybe.	D: I don't think <b>it's the subject</b> .
D: That's right.	B: I think you can write about <i>the difference in the position of the researcher</i> .
B: Moreover, as D was saying earlier, there are two kinds of diet. There may be a difference in the focus of research between those who say they are healthy and those who say they can lose weight. It's true that there may be <b>a difference in the focus of the research</b> . I also wonder if there is something else going on.	D: Also.... There may be <b>a difference in the duration of time</b> .
D: The target <b>subjects are different</b> , aren't they?	B: Certainly, there is that.
B: That's true. I think it is true that the <b>number of subjects is different</b> . I wonder if it's <b>the sample size</b> .	D: If you look at it in the long term, it's harmful, but if you look at it in the short term, like six months, it's good for your health.
D: And it's only women.	B: That's true.
B: That's true. Is it the subjects or the research subjects? I don't know. Isn't <b>the research subject different</b> ?	D: Maybe. Any other things?
D: Yes, the research subjects. The other thing is...	B: That's about right, isn't it?
C: Another thing I thought of was that (Document) No. 5 is said by a nutritionist, and (Document) No. 4 is said by a medical doctor. <i>There is a difference in the position of the person saying it</i> .	== Later ==
B: I see.	D: I think that <b>the difference in the duration</b> is caused by <b>the difference in focus (of research)</b> . I think that's the biggest thing.
D: Does it <i>change your point of view</i> ?	C: If the focus is adjusted, they match, don't they?
B: That's important, isn't it?	D: Yes, I knew that.
C: Does that mean that <b>the subject of the research is different</b> ?	B: That's deep.
B: I don't know. I wonder if there is <i>a difference in research</i> .	D: Like that? I guess it's like that. Even if you're in <i>a different position</i> , as long as your focus is right, right? In the end, <b>it's all about focus</b> .
	B: That's right, positions. There are a lot of <i>differences in positions</i> , even in other research, I guess.

As shown in Table 3, the group in Case 1 referred to the disagreement reasoning tags quite frequently when discussing the reasons for disagreements among the presented pieces of information. These students also generated additional reasons for disagreement on their own. They were able to integrate conflicting information to reach their conclusions based on the information presented in the documents, using “different duration” and “different research focus” to sort through the various perspectives presented in the documents. As a result, they concluded that “low-carbohydrate diets are effective in the short term, but rather than being effective in the long term, they are harmful for health,” and that “the Mediterranean diet is better in the long term.”

This case illustrates that when students use the epistemic scaffolds to analyze evidence and expert perspectives, and when they use epistemic scaffolds for reasoning about disagreements, they are more successful at integrating information from the documents to reach a reasonable conclusion. Using these scaffolds can help students attend carefully to the new information they encounter and not just rely on prior beliefs.

## Discussion and conclusion

The EDDiE project aims to develop and investigate a web-based CSCL system in which students analyze multiple conflicting documents through collaborative interaction to create a graphical analytic tableau. In this paper, we have briefly described the EDDiE system and have reported a comparative case study of student groups in an

undergraduate class using EDDiE. Across the seven groups, including groups not described in this report, the epistemic scaffolds elicited productive epistemic discourse around evidence, sources, claims, and resolution of disagreements among multiple documents. Analyses of the full transcripts (beyond the scope of this report) revealed that the students engaged in epistemic discourse spanning all five dimensions of the Grasp of Evidence framework—analyzing study components such as sample size, evaluating methodological quality, interpreting evidence, examining which positions are supported by a larger body of high-quality evidence, and considering the extent to which experts agree. In addition, students effectively reasoned about the disagreements and made integrative judgments when they used the disagreement reasoning tags as epistemic scaffolds.

Our initial findings in the comparative case study suggested the need for design revisions to further support students' efforts to resolve disagreements and integrate the documents in order to reach sound conclusion. For example, we now believe that the use of the disagreement reason tags should be explicitly prompted at the moment when students begin to integrate pieces of conflicting information. Several groups failed to use the disagreement reasoning tags; these groups had difficulty reaching integrative conclusions that were based on the information presented on the documents; instead they relied primarily on their prior beliefs. Furthermore, in order to foster positive motivations and emotions as students encounter potentially frustrating conflicts in information, metacognitive discussions may be beneficial (see Barzilai & Chinn, 2018); students could discuss why it is valuable to deal with conflicts and try to resolve them, despite the challenges. Such metacognitive discourse can also function as expansive framing (Engle et al., 2012) that enhances transfer of what students learn with EDDiE. That is, when students explicitly label and justify use of different strategies for resolving disagreements, these strategies can become more available for use in other settings (Chinn et al., 2020).

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