

Effects of Video-Based Peer Modeling on the Question Asking and Text Comprehension of Struggling Adolescent Readers

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Abstract

Good readers ask questions during reading, and this is presumed to improve their text comprehension. But what about not-so-good readers? Does question asking promote comprehension for struggling readers and, if so, how can we best support these students? This paper examines question generation among low-performing sixth-graders who read moderately-challenging science texts. It characterizes the nature of students' questions and describes the effects of a video-based peer modeling intervention on their question asking and reading comprehension. In contrast to previous research, this study found that students asked a large number of deep reasoning questions, particularly those related to identifying goals, processes, causes, and consequences. However, such questions were not generally associated with greater understanding. Only two types of deep reasoning questions were related to text comprehension—those that were *not* answered in the text (directly or indirectly) and those that students labeled as “I’m Confused” questions. The study also found that readers who were exposed to video-based peer modeling of question generation asked more of these types of questions and scored significantly higher on multiple measures of text comprehension. These findings have implications for the design of systems to support struggling readers and for theory-building about question generation.

Introduction

To deeply comprehend a text, students must *construct a coherent, accurate and actionable representation* of this text in memory (Kintsch 1998). Once they have such a representation, readers may *critique* the text, *relate* it to their existing knowledge, *integrate* it with other information, and *extend* its implications to other contexts.

Question generation is thought to promote deep-level comprehension in several ways—by focusing the reader’s

attention on the content of the text, supporting the reader in maintaining an active stance during reading (Sinatra, Brown, & Reynolds 2002), stimulating inferencing and explanation (King & Rosenshine 1993), sensitizing the reader to what she does not understand in the text (Palincsar & Brown 1984; Rosenshine et al. 1996), and helping the reader to create more situated representations of new content (King, Staffieri, Adelgais 1998).

Leveraging Social Aspects of Learning

To support deeper-level comprehension, many computer-based learning systems create *simulated social environments*. Animated agents, generally appearing as talking heads or characters, act singularly or in ensembles to model strategy use and to participate in learning conversations with students. For example, in the iDRIVE program, a tutor agent and student agent engage in virtual conversation around science content (Graesser et al. 2008; Gholson & Craig 2006). The student agent models the asking of deep-level questions; the tutor answers them. Similarly, in the introductory module of the iSTART program, a trio of agents converse among themselves: The professor agent instructs two student agents and answers their questions (Graesser et al. 2008; Graesser, McNamara, & VanLehn 2005; McNamara, O’Reilly, Rowe, Boonthum, & Levinstein 2007). In both of these examples, student learners observe agents asking and getting answers to their questions.

The present research builds upon and extends the idea of leveraging social mechanisms to support readers’ question asking and comprehension by: (1) Using videotaped peer models (real children) rather than animated pedagogical agents to prompt question generation; and (2) structuring the social interaction as one of supportive friendship rather than instruction (e.g., tutor-tutee).

Peer Modeling and Learning

Peer modeling is uniquely well-suited to the needs of adolescent learners—students who tend to define themselves in relation to their peers (fitting in and standing out) and who are more concerned with social norms and susceptible to peer influence than younger children (Brewer 1991; Steinberg 2008; Wigfield et al. 1996; Wigfield et al. 2006).

Peer models can both inform and motivate learners (Schunk & Zimmerman 2007). Motivationally, they can demonstrate enthusiasm, competence and the possibility of success, thereby inducing the same in their learning companions (Ginsburg-Block et al. 2006). Furthermore, peer models can mitigate the *social risks* associated with question asking (e.g., the loss of status adolescents risk when they “reveal ignorance” or ask a “bad” question). They help low-performing readers recalibrate their social norms by recognizing that their questions are not stupid and they are not alone in their confusion. (These sentiments were voiced by students in pilot research.)

When positioned as supportive friends, peer models can also support cognitive aspects of learning. They can provide authentic examples of strategy use that may be closer to the zone of proximal development (ZPD) of struggling readers (Vygotsky 1978). The models do not show “expert” strategy use. Rather, they demonstrate good strategy use in ways that are comprehensible and meaningful to lower-performing readers.

Research Objectives

The goals of this study were to characterize the types of questions lower-achieving readers asked in trying to make sense of moderately-challenging science texts; to identify the types of questions associated with text comprehension; and to examine the effects of peer modeling of question generation. Exposure to peer models was expected to deepen the question asking of participants and to improve their text comprehension. However, the opposite was also plausible in the event that viewing models substantially increased cognitive load for or distracted participants.

Methods

Participants

Participants in this study were 48 sixth-grade students who attended public middle schools in New York City in 2011. Sixty-nine percent were girls, and 31% were boys. The mean age of participants was 11.25 years, and all were fluent speakers and readers of English. At the start of the study, 85% of participants were classified as reading at a “Basic” level (Level 2) and 15% were “Proficient” readers (Level 3). Initial levels of reading comprehension were

assessed with the Scholastic Reading Inventory (SRI), a computer adaptive test of reading comprehension.

Participants were randomly assigned to an experimental condition: 20 students were assigned to the Control group and 28 to the Peer Modeling group. There were no differences in these groups in terms of age, sex, reading accuracy, or baseline level of comprehension.

Materials

The study employed five sets of original materials: (1) an animated PowerPoint tutorial on question asking as a strategy for improving reading comprehension; (2) four 300-500 word expository science texts; (3) video clips of ethnically diverse middle-school students asking their own “thinking questions” about these texts; (4) a computer-based reading environment that presented texts, displayed video clips, and provided vocabulary support and question prompts; and (5) a Question Worksheet.

Data for two of the four experimental texts were analyzed for this paper. These two texts were high-interest, *problem/solution* texts—they both described a problem, its solution, and various circumstances surrounding the phenomenon. The easier text on the topic of vampire bats had a Flesch-Kincaid readability level of 5.9 and a Coh-Metrix Causal Cohesion Score of 0.846. The slightly harder text about the John Hancock Tower had a Flesch-Kincaid readability level of 6.9 and a Coh-Metrix Causal Cohesion Score of 0.632. Participants were assigned to read and understand one of these texts.

Participants’ questions about the text were collected through a Question Worksheet. On this piece of paper, students recorded their questions. They also indicated whether they had thought about the answer to the question and whether it was an “I’m Confused,” an “I Wonder” or a “Think and Search” type question. (Please see Appendix for texts and an example Question Worksheet.)

Measures

Several outcomes were evaluated in the study.

Reading comprehension was assessed with multiple measures. A Structured Oral Retelling and Oral Text Summary measured participants’ recall of idea units and critical idea units as well as their situation level understanding (or misunderstanding) of the key problem/solution elements of the text.

A written Sentence Verification Task (SVT) was also used to assess overall passage comprehension. On this test, students read paraphrase and meaning change sentences and then indicated which sentences were consistent with the message of the text. The SVT is believed to be less susceptible to prior knowledge influences than other comprehension measures (Royer 2004; Royer & Sinatra 1994).

Reading motivation was assessed through a survey that participants completed upon finishing the reading activity. Self-report items measured their interest in the text, positive and negative affect, and preference for challenge in future texts.

Nature of question asking was assessed by examining the incidence and type of questions that students recorded on their Question Worksheet after reading the assigned experimental text.

Reading fluency was assessed by scoring excerpts of participants' oral text readings (Read Alouds) for accuracy, types of errors and rate of self-correction.

Procedures

After parental consent was obtained, participants completed the SRI and a Pre-Survey of Reading Habits. Based on their SRI score and gender, they were matched with one or two other students and with an experimental text that was deemed to be moderately challenging. Participants were then randomly assigned to an experimental condition.

Students in the Control group received question-asking strategy instruction without peer support. Then, they read the assigned experimental text, a 300-500 word problem/solution science article on either vampire bats or the John Hancock Tower. They first read the passage aloud and then, if they wished, they read it a second time silently. After reading, they recorded their questions on a Question Worksheet. The text was presented in a computer-based reading environment that also provided vocabulary support upon request.

Matched students in the experimental group received the same strategy instruction and commenced reading the same expository text. However, they also received social support in the form of videotaped peer models. Prior to reading the text aloud and then again after reading it, these participants watched short, embedded videos of same-age, similar-ability peers asking authentic questions about the experimental text. The videos appeared automatically, and participants were able to replay them if desired. Students then recorded their questions.

Following the reading and question-asking activities, all participants completed a Post-Survey of Reading Motivation and the oral and written comprehension assessments.

Data Analysis

Sources of data were participants' survey responses, SVT test scores, recorded questions, and Oral Text Summaries.

Coding of Questions

Participants' questions were scored for question type and depth (deep, intermediate, or shallow) using Graesser & Person's (1994) question taxonomy. They

were also scored for the extent to which they were answered in the text (directly answered, indirectly answered, or not answered).

A team of three independent raters reviewed and scored each question. Disagreements in scores were adjudicated by the author. After approximately eight hours of training, raters reached category agreement of at least 75% for all scoring dimensions.

Coding of Oral Text Summaries

Data from Oral Text Summaries were transcribed and scored on five dimensions: Understanding of the problem, understanding of the solution, amount of detail recalled, *misunderstanding* of critical ideas, and application of world knowledge, i.e., inclusion of information that was not provided in the text.

Examples of misunderstanding included participants thinking that the shot given to farm animals vaccinated them against rabies; that vampire bats killed animals by sucking too much of blood; or that the John Hancock Tower was abandoned.

Examples of knowledge application included the following sorts of statements from participants:

- The problem about the glass was that it was too thick and couldn't stand the Boston wind. Like when your hair is thick and it can break easy, like that.
- So a lot of animals were dying and if the farmer doesn't have a lot of animals it's kind of bad business.

A team of three independent raters reviewed and scored each Oral Text Summary. Disagreements in scores were adjudicated by the author. After approximately two hours of training, raters reached agreement of at least 70% for all scoring dimensions.

Results

Incidence and Type of Questions Asked

The 48 low-performing readers in this study asked a total of 152 questions. The number of questions per participant ranged from 0 to 5, with an average of 3.17 questions.

Of the questions asked, 22% were answered directly in the text, 21% were answered indirectly in the text (they required students to make inferences across sentences and paragraphs), and 51% were not answered in the text. Participants' characterized 61% of their questions as "I Wonder" questions; 22% were labeled as "I'm Confused" questions

Nearly two-thirds of questions (62%) were deep-level questions that probed goals, causes, consequences or mechanisms/processes related to the problem or solution presented. About 26% of questions were shallow and 11% were intermediate level. Table 1 summarizes these data.

Table 1
Summary of the Incidence and Types of Questions Asked by Struggling 6th Grade Readers

Question Type	Number Mean (SD)	Proportion of Total Mean (SD)	Example
Number of Questions Asked	3.17 (1.374)	-	
"I'm Confused" Questions	.68 (.887)	.22 (.287)	I'm confused. If the bat were killing animals, why didn't the farmer keep them [the animals] inside?
"I Wonder" Questions	1.89 (1.220)	.61 (.402)	I wonder why John Hancock building wanted to make his building unique and not the same as other buildings?
Directly Answered in Text	.66 (.788)	.22 (.278)	Why did they want to make a building out of glass?
Indirectly Answered in Text	.62 (.677)	.21 (.271)	Why didn't Pei use wood?
Not Answered in Text	1.76 (1.139)	.51 (.320)	How could wind break the glass?
Shallow Questions	.89 (1.026)	.26 (.312)	Did anybody else make a building out of mirror glass?
Intermediate Questions	.41 (.617)	.11 (.158)	Is the John Hancock Building taller than the Twin Towers?
Deep Questions	1.91 (1.265)	.62 (.362)	How can slightly thicker blood make a vampire bat choke?

Because participants asked such a high proportion of deep-level questions, these were further classified by whether or not they were answered in the text and by their designation as deriving from a state of confusion or curiosity. These more nuanced classifications were used in later analyses.

There were no significant differences in the number and types of questions by gender or specific text in any of the question quality measures.

Level of Text Comprehension

Participants had difficulty understanding these texts. More than half (53%) were judged as *misunderstanding* critical elements of the texts. In particular, they seemed to struggle with the solutions that were presented in the texts. Out of a possible 3 points, the mean score for solution understanding was 1.4 (SD=.970). In contrast, the mean score for problem understanding was 2.36 out of a possible 3 points (SD=.673)

Students averaged 67% on overall text comprehension (a score computed from problem, solution, and detail component scores). Similarly, they averaged 74% correct on Paraphrase items and 46% correct on Meaning Change items of the written SVT assessment.

Boys and girls scored comparably on comprehension measures. However, boys scored significantly higher than girls on SVT-Paraphrase items: They answered 82% of the questions correctly, whereas girls answered 70% correctly, $t(46) = 2.18, p < .05$.

There were also differences in comprehension by text. Participants reading the article on Vampire Bats recalled

significantly more idea units and critical idea units than those reading the John Hancock Tower text, $t(46) = 2.186, p < .05$ and $t(46) = 3.009, p < .01$ respectively.

Question Asking and Text Comprehension

Correlations were run on question and comprehension measures to assess the ways that question asking might support text comprehension. A number of interesting associations were found.

Asking questions that were *directly* answered in the text, regardless of whether these questions were deep or shallow, was negatively correlated with many measures of comprehension. Conversely, asking questions that were *not answered* in the text was positively correlated with comprehension.

Several measures of question generation were *not* correlated with comprehension. There were no significant associations between comprehension and the total number of questions that participants asked, the percent of "I'm Confused" or "I Wonder" questions, or the absolute level of questions asked (deep, intermediate, or shallow).

On their own, deep questions were not related to comprehension. However, when students asked deep-level questions that originated from a state of confusion, they were less likely to misunderstand critical ideas in the text. Likewise, when they asked deep-level questions that were not answered in the text, they scored higher on many measures of text comprehension. Table 2 presents correlation data for question attributes that were related to comprehension.

Table 2
Correlations between Question Types and Text Comprehension

Question Type	Measure of Text Comprehension							
	Overall	Soln	Prob	Misund	IdUn.n	CrtId.n	SVT_pp	SVT_mc
1. Questions <i>directly</i> answered in text (%)	-0.348*	-0.319*	-0.404**	0.334*	n.s.	-0.342*	n.s.	n.s.
2. Questions <i>not</i> answered in text (%)	.304*	n.s.	n.s.	n.s.	.295*	.342*	n.s.	n.s.
3. Deep-Level Questions Labeled *I'm Confused* (#)	n.s.	n.s.	n.s.	-.316*	n.s.	n.s.	n.s.	n.s.
4. Deep-Level Questions <i>not</i> answered in text (#)	.296*	n.s.	n.s.	n.s.	.417**	.415**	n.s.	n.s.

Note. N=48. Overall Text Comprehension-Percent Score based on Oral Text Summary (Overall), accurate understanding of Solution based on Oral Text Summary (Soln), accurate understanding of Problem based on Oral Text Summary (Prob), Misunderstanding of Critical Ideas based on Oral Text Summary (Misund), number of Idea Units Recalled (IdUn.n), number of Critical Idea Units Recalled (CrtId.n), percent Paraphrase items correct on SVT test (SVT_pp), percent Meaning Change items correct on SVT test (SVT_mc)

* $p < .05$, ** $p < .01$

Effects of Peer Modeling on Question Asking

A 2 x 2 between-subjects multivariate analysis of variance (MANOVA) was performed on the four measures of question asking that were correlated with comprehension: percent of questions directly answered in text; percent of questions not answered in text; deep-level questions identified as "I'm Confused" questions; and deep-level questions not answered in the text. Independent variables were experimental condition (Control and Peer Modeling) and text (Vampire Bats and John Hancock Tower). SPSS GLM procedures were used for the analyses.

Motivational variables such as text interest, preference for challenge, negative and positive affect scores, and judgment of learning were assessed as possible covariates. Surprisingly, none of these variables was strongly correlated with any of the dependent variables. Consequently, no covariates were included.

With the use of Wilks' criterion, the combined DVs were significantly affected by experimental condition, $F(4, 40) = 2.860$, $p < .05$. They were not significantly affected by experimental text or by the interaction between condition and text.

Further analyses of individual DVs showed a significant effect of experimental condition on deep-level questions not answered in the text, $F(1, 40) = 4.732$, $p < .05$. Participants in the Peer Modeling condition asked more of these questions ($M=1.21$, $SD=.995$) than did students in the Control group ($M=.70$, $SD=.801$).

There were also *trends towards significance* for two other measures of question quality—the number of deep-

level questions labeled as "I'm Confused," $F(1,40) = 2.150$, $p=.061$, and the percent of questions not answered in the text, $F(1, 40) = .307$, $p=.079$. In both cases, students in the Peer Modeling condition asked more of these questions than did those in the Control group.

Effects of Peer Modeling on Comprehension

The same type of MANOVA was performed on six measures of text comprehension: Overall Comprehension-Percent Score; Understanding of Solution; Understanding of Problem; Misunderstanding of Critical Ideas; Number of Idea Units recalled; and Number of Critical Idea Units recalled.

With the use of Wilks' criterion, the combined DVs were significantly affected by experimental condition, $F(6, 38) = 3.435$, $p < .01$ and by experimental text, $F(6, 38) = 4.480$, $p < .01$, but not by their interaction.

Further analysis of the individual comprehension DVs showed that experimental condition had a significant effect on Understanding of Solution, $F(1, 38) = 6.522$, $p < .05$, and Number of Critical Idea Units recalled, $F(1, 38) = 4.340$, $p < .05$. Participants in the Peer Modeling Group ($M=1.63$, $SD=.839$) understood the solution element of these two texts better than their peers in the Control Group ($M=1.10$, $SD=1.107$). Similarly, students who viewed the peer models of question generation recalled more critical idea units than their peers.

Experimental text had a significant effect on these same two comprehension variables as well as the Number of Idea Units recalled.

Discussion

There are several surprising findings in this study that warrant further investigation. That these low-performing readers asked such a high proportion of deep-level questions is especially noteworthy. Previous research has indicated that students typically ask only a few questions and that most of these are shallow-level (Graesser & Person 1994). The unusual finding in this study may be due to the age of participants—perhaps these 6th graders were more curious or more confused than older students. It may also be related to text features. The experimental texts were high-interest and within the ZPD of the student, not too hard or too easy. They were also problem/solution texts, and this text structure might invite questioning.

The high number of questions and deeper-level questions, however, might also be related to the *social environment* of the task. In the study, participants faced no social risks for asking their questions. Those in the Peer Modeling condition might have even obtained social benefits for question generation. For example, they might have felt as though they were participating in a desirable social norm or, on the other hand, that they were better than the peer models.

Another interesting finding is that deep-level questions were not necessarily related to text comprehension. Among struggling readers, certain types of questions (such as questions that are directly answered in the text) may be markers of reading difficulty. If detected, they could be used to pinpoint the areas of misunderstanding and to promote deeper comprehension.

Furthermore, the finding that deep-level questions originating from a state of confusion are correlated with greater comprehension may lend some support to theories of Cognitive Disequilibrium and deserves more attention.

A third surprise was the lack of some predicted relationships in the data, e.g., the relationship between motivational variables and question asking. At minimum, text interest was expected to correlate with question asking. Non-significant results such as this warrant further examination. If interest is not driving question asking among lower-performing readers, what is?

Finally, the positive effect of video-based peer modeling on adolescents' question asking and text comprehension is an encouraging finding with implications for the design of learning support systems. Future analyses will examine the possible mechanisms by which peer models promote question asking and text comprehension.

Implications

This study has implications for the design of computer-based learning environments and theory-building around question generation.

In developing systems to support reading comprehension and deeper-level science reasoning, designers may wish to consider using human models rather than relying entirely on animated pedagogical agents. While real children ask less predictable questions than programmed agents, the authenticity, intention and expression (non-verbal and verbal) of their questions may provide learners with a more impactful experience on many levels. Simultaneously addressing multiple channels of learning (social, motivational, and cognitive) may be an effective way to enhance learning and understanding.

Researchers studying question generation may also wish to leverage the lessons of this study by modifying some of the current question coding frameworks. In particular, it may be worth qualifying the system for coding question types as deep, intermediate or shallow to include information on the extent to which such questions are addressed/answered in the learning materials.

Acknowledgements

This research was supported by the Carnegie Corporation of New York/National Academic of Education Adolescent Literacy Fellowship Program, which provided generous funding as well as much-appreciated mentoring, and by a 2011 Dissertation Grant from the City University of New York. Scholastic, Inc. also provided free licenses for the Scholastic Reading Inventory (SRI), a computer adaptive assessment of reading comprehension.

I would like to extend special thanks to Dr. Barry J. Zimmerman for his gentle and insightful advisement over many years; to my data coders who lent their considerable intelligence and dedication to this project; and to my ever-supportive and encouraging family and friends.

Appendix

Text 1: Vampire Bats

Are there really such things as vampire bats that suck people's blood? Dracula was a character in a book who was supposed to have been a bat part of the time and an evil man after dark. However, everyone knows that Dracula is a made-up person.

But there really *are* vampire bats in South America. They don't turn into men after dark, but they do live by sucking blood from humans and animals. In fact, blood is the only thing they eat.

The vampire bats of South America have many unique physical features. They are very small—three inches in length. When they stretch their furry wings, their wingspread is only about as long as a piece of paper. Their wings are soft, so they can fly quietly and not be heard by

their prey. They have razor-sharp teeth, pointed ears, and an ugly face. Like other bats, they are blind and fly using radar. In other words, they bounce a high-pitched sound off things in front of them and listen for the echo.

Vampire bats can't kill a human, cow or horse because they suck only a small amount of blood. But a few years ago, when many horses and cows in South America were dying, people blamed the vampire bats. This is what *really* happened.

One or more vampire bats bit a dog or other animal that had a disease called rabies. When the bats sucked the animal's blood, some of the germs of the rabies disease got into the bat's teeth. When the bat flew to another animal and bit it, the germs infected the second animal with rabies. So the vampire bats were spreading this horrible disease from one animal to another. Thousands of animals were dying from rabies, and the farmers became angry.

For a long time, no one could think of a way to stop the vampire bats from spreading rabies. People could not shoot the bats because they were too small, and there were too many of them. The bats couldn't be poisoned because the only thing they ate was blood and that would mean poisoning farm animals!

Then some scientists had an idea. They gave cows and horses a special shot that made their blood slightly thicker. When the vampire bats sucked this thicker blood, it choked and killed them. These shots were successful in keeping the number of vampire bats down and in saving the lives of many animals.

Text 2: The John Hancock Tower

In 1972, the John Hancock Company—an insurance company—decided to build the tallest building in Boston. This building was called the John Hancock Tower, and it was to stand 60 stories tall.

The building was very unusual. The architect, a Chinese-American man named I.M. Pei, made the building in the shape of a parallelogram. Pei also made all the walls of the building out of mirror glass. This is a special glass that reflects light just as a mirror does. If you look at the building from the outside, you see the reflection of other buildings, the clouds, and the sky. However, if you are inside the building, you can look out through the glass as you normally would.

Pei and his design team used this kind of mirror glass for two reasons. First, they thought it would make the building look unique. Second, this kind of glass saves money on air conditioning in the summer. The sun's rays reflect off the glass and, therefore, don't heat up the inside of the building as much.

When most of the huge pieces of glass had been installed, something terrible began to happen. One by one, the panes of glass began to break. Most of them were

broken by strong winds, and the pieces fell down the side of the building and broke or scratched other windows. Each pane of glass cost more than \$700. Every time one broke, workers had to take out the pieces that were left and put in a sheet of plywood.

The John Hancock people realized that the glass over the whole building was not thick and strong enough for the winds of Boston. Nobody could move into the new building until they figured out what kind of glass to use, took out all the old pieces and the plywood, and installed new glass.

In the meantime, the glass kept breaking. On one windy day in the winter of 1973, more than 1,000 panes of glass broke. The police had to close the streets below to keep anyone from being hit by falling glass. Someone had made a terrible mistake about the glass, and changing it would cost the John Hancock Company seven million dollars or more! But when the new glass was finally installed, the building came to be regarded as one of the most beautiful skyscrapers in the world.

Example of Question Worksheet

Figure 1 shows an example of a Question Worksheet completed by a participant in the study.

Figure 1
Question Worksheet

Your Smart Questions Worksheet

Project ID: [redacted] Date: 11/14/11

INSTRUCTIONS

1. Please write as many of your own questions as you'd like on this Worksheet.
2. Write one question in each block.
3. Check off what type of question each one is.
4. Check off whether or not you tried to answer this question by re-reading the text, connecting information in the text or thinking about possible answers.

Your FIRST Question:
Can a bat tell if a animal has rabies?

➤ What type of question? ☐ Think & Search ☒ I Wonder ☐ I'm Confused
➤ Did you try to answer this question? ☐ Yes ☒ No

Your SECOND Question (if you have another):
how do bats find fly if there blind?

➤ What type of question? ☐ Think & Search ☐ I Wonder ☒ I'm Confused
➤ Did you try to answer this question? ☐ Yes ☒ No

Your THIRD Question (if you have another):
why are vampire bats so small in size?

➤ What type of question? ☒ Think & Search ☐ I Wonder ☐ I'm Confused
➤ Did you try to answer this question? ☒ Yes ☐ No

Your FOURTH Question (if you have another):
How can slightly thicker blood make a vampire bat chase

➤ What type of question? ☐ Think & Search ☐ I Wonder ☒ I'm Confused
➤ Did you try to answer this question? ☒ Yes ☐ No

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