Grassroots open, online, calculus help forums

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Abstract: The emergence of free, open, online, help forums has transformed tutoring from a private and individual activity into a public and collective endeavor. These forums support asynchronous exchanges between individuals from around the world. Students visit these forums seeking help on specific queries from coursework and receive help from anonymous others. In contrast to help forums designed and supervised by educational researchers, these forums have a grassroots origin. This paper investigates one such calculus help forum for evidence that forum tutors are scaffolding students to contribute to the successful solution of the exercise they posted. An analysis of 200 exchanges on limit and related rates revealed the presence of effective guided problem solving (marked by leading questions and hints), albeit to a limited extent. This work points to the need for discovering ways to augment constructive interactions in popular help forums that have become part of the student learning experience.

Introduction

Traditionally, tutoring is conducted as a private activity between a single tutor-tutee pair or small group of students. However, on the Internet, tutoring can be conducted as a public activity that connects people who share an interest in a certain subject domain with students seeking help. Via open, online, help forums, students communicate with a network of others around the world, seeking help on specific questions regarding coursework wherever and whenever they arise. At the same time, these forums connect the "network of others," a group of people who have the time, experience, and willingness to work on mathematics with students and (in some cases) with one another. Many of the open, online help forums operate free of charge and are staffed by volunteer subject enthusiasts, educators, and advanced students.

Open, online help forums are websites where students can post course-related queries that are then visible to the public. These forums are "open" in the sense that participation is not limited to any particular course or institution; members of the general population are attracted to them by necessity and interest. People learn of the forums' existence, access the web sites, and then choose whether or not to join in the conversation, either by posting a question or voluntarily acting as tutors to anonymous others. Because the exchanges take place on public websites, asking and answering questions effectively takes place "in a fishbowl." What is the nature of the activity that is supported by adding this broader social dimension to tutoring?

Tutoring in asynchronous environments

The Vygotskian (1978) notion of learning through social and cognitive interaction with a more experienced peer in the context of a task that lies within the tutee's "zone of proximal development" (Topping, 1996) has made its mark on computer-supported learning environments. In particular, the affordances of the Internet have been harnessed to support asynchronous interactions between students learning mathematics and more advanced others. For example, The Math Forum is a premier interactive digital library that, amongst other activities, houses an online mentoring program (Problem of the Week) that supports scaffolded problem solving of non-routine word problems from mentor teachers (Renninger, Farra, & Feldman-Riordan, C., 2000; Renninger & Schumar, 1998). At this site, students can also submit their own questions (either curiosity- or assignment-based) and receive an answer via e-mail from a volunteer staff member (Ask Dr. Math). The 'doctors' in this program undergo a tenure process and are required to demonstrate proficiency in content knowledge as well as communication and diagnostic skills (Underwood et al., 2006).

In contrast to these environments that connect *significantly more experienced* others with students learning mathematics, forums supporting asynchronous discussions of routine (homework) exercises between *peers* have also been designed (Kortemeyer, 2006). This forum, that is connected to the online physics homework system LON-CAPA, allows students who are enrolled in the same course but who do not necessarily meet in face-to-face instruction to interact and help one another (anonymously) as they work on similar homework assignments, with occasional input from an instructor. LON-CAPA provides randomized computer-generated problem statements to students (different numbers, choices, graphs, images, parameters, etc.) so that the discussion threads reference different versions of the same exercise.

In addition to these *designed* online tutoring environments, there are a number of *grassroots* forums that have sprung up on the Web, presumably in answer to a global need for accessible and affordable help. These sites are generally supported through advertisements and are open to the general public. In many ways, they resemble a blend of the designed environments that have been crafted by educational researchers. Like The Math Forum, these forums allow students to submit and receive help on specific queries; like the LON-CAPA forum, some open forums allow any member to contribute to an ongoing thread. Unlike the Math Forum, in an

open forum all contributions are publicly available (although private messaging may be permitted); unlike the LON-CAPA forum, members of the general public can participate in these open forums. FreeMathHelp.com, the open forum that is the focus of this paper, has the following characteristics: open to the general public, permits any member to contribute to an ongoing discussion, anonymous participation, student-initiated help-seeking on specific exercises from coursework, and all threads are publicly available and archived.

Is there any evidence of effective tutoring in the brief encounters within a natural and unsupervised forum community? One mark of effective tutoring that has been identified in both laboratory investigation and naturalistic observation encapsulates the notion of scaffolding and the tutee's zone of proximal development: Although the learner is involved in what is initially, for them, 'out of reach' problem solving, the tutor ensures that they play an active role in learning and that they contribute to the successful solution of problems (Rogoff, 1990). This indicator is also appropriate for the purpose of this investigation since students initiate dialogues in the grassroots forums precisely when they are seeking help from more experienced others 'out there' on exercises that are initially, for them, 'out of reach.'

Methods

Vocabulary

There is a vocabulary associated with asynchronous interaction in online environments that is used for this discussion of online tutoring. An Internet *forum* is a web application for holding discussions and posting user-generated content. The term "forum" is used to refer to the entire community as well as to any sub-forum dealing with a distinct topic. A *post(ing)* is a contribution or message that is published on the site, either to initiate a discussion or in response to another's contribution. The set of contributions pertaining to a single request for help constitute an *exchange* or *discussion*, sometimes referred to as a *topic* or *thread*. These threads are displayed on the entry webpage of the forum and designated by the subject header or title of the initial post.

Design

In order not to disrupt activity in the online forum in any way, a purely observational and non-intrusive methodology was adopted. A sample of 100 exchanges on the limit and 100 exchanges on related rates (both dating back from 4/29/08) was collected from the archives of the calculus homework help forum on the site, FreeMathHelp.com.

Site choice and description

The calculus forum at the FreeMathHelp.com site was selected from several existing open, online, calculus help forums because it has an extensive history (archives dating back to 2005), includes a search mechanism for locating exchanges by a keyword or phrase, and is active in terms of daily postings and membership.

FreeMathHelp.com is an advertisement-supported mathematics help portal established in 2002 by Ted Wilcox, then an enterprising high school junior. The site contains 10 homework help forums organized by subject area (ranging from arithmetic and pre-algebra to calculus and differential equations). The sole requirement for becoming a forum member is registration (which entails agreeing to abide by terms for permissible content and/or conduct, providing a username and e-mail address, and selecting a password). Forum members can initiate threads in a discussion forum (e.g. as students posting mathematics questions) and can respond to others' posts (e.g. as tutors providing help). Forum members also have access to user profiles that include self-volunteered information on occupation, residence, contact information, as well as statistics on discussion board activity.

Each forum has moderators assigned by the site administrator who may lock topics and move, delete, or edit postings. In addition, members can edit their own contributions after they have been posted: If this is done after the member has logged off of the forum, then a message is appended to the altered contribution: "Last edited by [member] on [date and time]; edited [number] times in total." If editing takes place while the member is still logged on to the forum, then there is no official evidence of the modification although the general practice is for the author to indicate that the contribution has been edited.

The prescribed etiquette for participation (or "netiquette," e.g., Shea, 1994) is located in a "sticky" that is the lead posting within each help forum. This covers administrative issues (e.g., posting to an appropriate category) and politeness (e.g., patience while waiting for response). In addition, there are three rules that specifically address the content and framing of posts: include problem context ("Post the complete text of the exercise"), show initial work ("Show all of your work [including intermediate steps that may contain errors]"), and attend to clarity ("Preview to edit your posts [to minimize errors]").

The computer window for constructing posts contains traditional icons for highlighting text (e.g. italics, boldface, underlining, and font size and color), inserting material (e.g. external links and images), and organizing text (e.g. forming lists). A large selection of graphic "emoticons" (faces) is available for expressing

emotions and attitudes (such as [Very Happy] and [Confused]), and LaTeX, a document preparation system, is available for typesetting mathematical text and symbols.

Topic choice

Students enrolled in "introductory calculus" are exposed to a large number of topics from differential and integral calculus. Although the exact coverage of the syllabus will vary across programs and institutions, there is a large amount of overlap in the topics that are presented. Two such topics, that reflect the diversity of problem types characteristic of the subject domain, are the limit concept and related rates. Both topics are challenging to students (Cornu, 1991; Cottrill et al., 1996; Engelke-Infante, 2007; Martin, 2000; Tall, 1993).

Sample characteristics

FreeMathHelp.com features participant profiles that include information on occupation, location, and interests. Whereas many student participants do not provide this information, the participating tutors in the calculus forum are self-reportedly students, educators, professionals, and retired mathematics professors. The most frequent tutor participants are from the United States, although there are representatives from a variety of other countries as well. In this paper, most participants are referred to by their self-designated user names or "handles" (such as *ihatecalc* or *skeeter*). However, if a user name appeared to reveal a participant's real world identity (such as a surname), a pseudonym was assigned to respect anonymity and privacy.

Although some tutors and students post more frequently, numerous tutors and students frequent FreeMathHelp.com. The sample contained 100 related rates exchanges initiated by 65 different students, with responses from 18 different tutors and 100 limit exchanges initiated by 67 different students, with responses from 23 different tutors. There was some overlap in participants (both students and tutors) across the two mathematical topics: 17% of these students posted queries on both limits and related rates, and 63% of the tutors provided assistance for both topics.

Coding

In order to characterize forum tutoring dialogue patterns, each exchange was assigned a participation code that tracks the number of participants, the total number of contributions in the exchange and the sequence of participation. For example, a code of 1231 would be assigned to a thread with four postings containing contributions from 3 different participants: a student [1] posted a problem and then two different tutors [2 and 3, respectively] responded, followed by a final contribution by the student [1]. These codes permit one to catalogue exchanges that involve multiple conversational turns, multiple participants, and multiple contributions by a single participant (in particular, by the student who initiated the thread). In addition, although the participation codes are agnostic with respect to the quality of the contribution (e.g. mathematical accuracy and depth, and pedagogical sensitivity), the codes can be used to identify threads in which the student remained involved throughout the exchange, and are therefore candidates for exchanges in which the tutor(s) scaffolded a student in the construction of a solution to the exercise that the student brought to the table.

Results

Five percent of the exchanges contained a scaffolding dialogue between a forum member or members with more mathematical expertise and a student who wished to accomplish a task that they were unable to initially complete. These interactions were characterized by extended, back-and-forth conversations in which the student was focally positioned as a co-constructor of the problem solution. Instead of acting as a source or transmitter of information in these exchanges, the tutors appealed to resources available to the students and encouraged them to ponder the mathematics involved in the construction of the solution. This was often accomplished through the provision of hints, a tactic that is employed by expert tutors and has been documented in computer-mediated one-on-one tutoring episodes (Hume, Michael, Rovick, & Evens, 1996).

Example of effective tutoring

Table 1 contains an exchange on related rates in which a tutor, *skeeter*, led a student, *kimmy*, to discover an error in her constructed solution. Ironically, *kimmy* produced the correct *numerical* answer to the exercise in her initial post. However, *skeeter* detected a flaw in the accompanying chain of reasoning and posed a series of progressively more direct questions to lead *kimmy* to this realization.

Table 1: Outline of exchange with tutor guiding the construction of the solution.

Author & Time	Post	Interactive trajectory
kimmy at 4:48 pm	What about this question:	**kimmy** posts her solution to the problem and seeks

	A police cruiser, approaching a right-angled intersection from the north, is chasing a speeding car that has turned the corner and is now moving straight east. When the cruiser is 0.6 km north of the intersection, and the car is 0.8 km to the east, the police determine with radar that the distance between them and the car is increasing at 20km/h. If the cruiser is moving 60km/h at the instant of measurement, what is the speed of the car. My work: Let y be the police cruiser Let x be the car being chased Let r be the distance between them. y= 0.6 km dy/dt = 60 km/h x=0.8 km dx/dt = ? r = ? dr/dt = 20 km/r Solve for r r^2 = y^2 + x^2 r^2 = 0.6^2 + 0.8^2 r = 1 Differentiate 2r dr/dt = 2y dy/dt + 2x dx/dt Sub everything in and get a value of 70 km/h for dx/dt	verification from a forum tutor
skeeter at 4:56 pm	your answer is correct, but I would like to know what **exactly** did you substitute in for dy/dt to determine dx/dt?	**skeeter** affirms the numerical answer but initiates a dialogue on the construction of the solution
kimmy at 4:58 pm	I substituted in 60 for dy/dt	**kimmy** responds to question from **skeeter**
skeeter at 5:05 pm	then dx/dt wouldn't work out to be 70 km/hr, would it? r dr/dt = y dy/dt + x dx/dt (1)(20) = (.6)(60) + (.8)(dx/dt) 20 = 36 + .8(dx/dt) 16 = .8(dx/dt_ 20 km/hr = dx/dt where is the mistake?	**skeeter** follows up on **kimmy**'s assertion, demonstrates its inconsistency, and positions **kimmy** to locate the source of the discrepancy
kimmy at 5:08 pm	My mistake or a mistake in the problem?	**kimmy** asks **skeeter** to provide more information
skeeter at 5:12 pm	your mistake.	**skeeter** locates the error as one that **kimmy** has made
kimmy at 5:12 pm	That wouldn't make sense, having a high speed car chaese, and the one being chased driving at 20 mi/h, now would it?	**kimmy** hypothesizes that the error is based on the problem situation
kimmy at 5:14 pm	I have no idea what I did wrong.	**kimmy** expresses inability to figure out the error
skeeter at 5:17 pm	why do you think I asked you about the value you used for dy/dt?	**skeeter** provides a more pointed hint that connects the

	what is actually happening to the distance "y" during the chase?	variable "y" with its referent in the form of questions for **kimmy**
kimmy at 5:31 pm	It is also decreasing! Ohh! That makes the 60 km/h a negative?	**kimmy** excitedly contributes the connection
skeeter at 5:37 pm	correct on the negative … note that the derivative itself is not decreasing, it's constant. Glad you figured that out yourself … now you'll remember it. 	**skeeter** carefully evaluates **kimmy**'s response to ensure mutual understanding and comments on **kimmy**'s active role in the construction
kimmy at 5:46 pm	Thanks a lot!	**kimmy** ends the exchange with appreciation

This exchange exemplifies how effective and exciting it can be for all involved when tutors in an online forum initiate student activity and participation through leading questions and hints. In this case, the result was an extended, back-and-forth conversation that culminated in the student discovering her initial flawed reasoning and that went well beyond an adjustment of a proposed solution. (The tutor could have simply informed the student that there was a sign error in her work.) Instead, with the help of the tutor and a channel of leading questions, the student was able to navigate a path to a valid solution.

Discussion

This glimpse of activity in a grassroots open, online help forum reveals how this environment can be a rich source of naturalistic tutoring episodes. There was evidence of forum members scaffolding others' problem solving and positioning students to participate actively in the construction of solutions. However, it is worth noting that these instances were not the norm. Discovering ways to increase the number of such interactions could improve the effectiveness of these popular forums and help students acquire the mathematical skills and techniques necessary to participate in disciplinary discourse.

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