Carla van de Sande (2010):
Assessing the quality of collaborative activity in open, online, calculus help forums.
In Gunnar Stevens (Eds.),
International Reports on Socio-Informatics (IRSI),
Workshop Proceedings of 9th International Conference on the Design of Cooperative Systems - COOP 2010, Aix-en-Provence, France, May 2010
(Vol. 7, Iss. 1, pp. 95-103)

# Assessing the quality of collaborative activity in open, online, calculus help forums

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**Abstract.** Open, online help forums allow students to anonymously post queries (usually problem-specific questions from assignments) that are then visible to others with Internet access. These forums are especially popular for homework-intensive subjects, such as calculus, and are not affiliated with any educational institution or a particular course offering. The organic nature of these forums affords researchers the opportunity to study naturally occurring collaborative activity between students and helpers, especially in forums that exhibit a strong sense of community. Quality can be assessed first through quantitative metrics and then through qualitative analyses of student and helper contributions. Based on observational studies conducted over the last several years, I propose three markers of student activity: the presence of assertions and proposals for mathematical actions, questions and challenges of others' proposals, and indicators of resolution. Likewise, I propose three ways that helpers contribute to quality: bringing mathematical practices to life, fostering alternative perspectives, and supporting mathematical accuracy. I believe that studying these exchanges will give insight into how to improve the design of communication interfaces and how to better assess the quality of collaborative activity in more regulated, structured contexts. Future work includes relating the nature of forum collaborative help to learning outcomes.

## 1 Introduction

Open, online help forums are found on websites and allow students to anonymously post queries (usually problem-specific questions from assignments)

that are then visible to others. These forums are "open" in the sense that, unlike other asynchronous communication tools (such as course forums or discussion boards), access is not restricted to any particular course or institution. Also, instead of hosting discussions based on the curriculum from a particular course, the forums cover broad school subject areas (such as mathematics, science, and business) at a range of course levels (from elementary to graduate). These forums are a help-seeking resource that democratizes education through technology (Larreamendy-Joerns & Leinhardt, 2006) and is currently available free of charge to any student who has Internet access.

Students from around the world access these forums when they are in need of help completing assignments or understanding course material, and this is particularly true for subject areas such as mathematics that are homework intensive and require students to construct solutions to exercises. For example, one such site (www.mathhelpforum.com) that offers help in arithmetic through higher mathematics, has over 29,000 members and received an average of 152 queries daily in 2009.

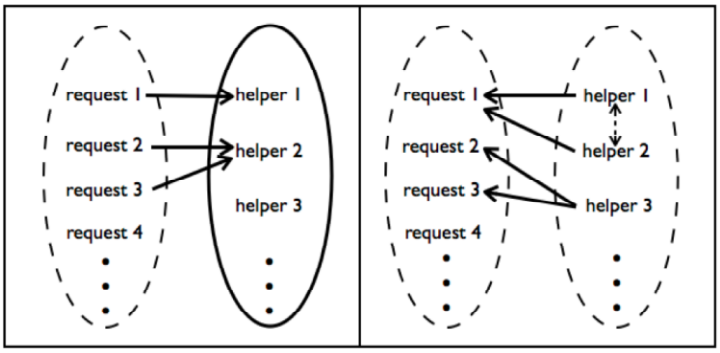


Figure 1. Alternative forum participation structures: AOH (left) and SOH (right)

Open, online, homework help forums belong to a genre of technology-assisted education called 'networked learning' (Goodyear, Jones, Asensio, Hodgson, & Steeples, 2005). The extent of the network and hence the affordance for collaboration depends, in part, on the structure of the forum (Figure 1). Some forums have a pool of select, vetted helpers to whom incoming queries are assigned, for example on the basis of expertise or availability (Assigned Online Help or AOH). Forums with this structure support one-to-one, computer-mediated help seeking between students and a restricted set of others who have met certain qualifications. Other forums, however, allow any member to respond to a query or contribute to an ongoing thread (Spontaneous Online Help or SOH). SOH forums provide a much more extensive help-seeking network with richer opportunities for collaboration (van de Sande & Leinhardt, 2007). In SOH forums, for example, helpers can dialogue with each other within a thread. A third possible forum structure, that is currently being researched (Puustinen, Volckaert-Legrier, Coquin, & Bernicot, 2009) is a blend of AOH and SOH in that the set of helpers is

more-or-less restricted and subject to approval (like AOH) but helpers can pick up any thread and interact with one another within threads (like SOH).

During our studies of calculus forums (van de Sande, 2008; 2010; van de Sande & Leinhardt, 2007; 2008), we have developed and applied several quantitative and qualitative metrics to assess the nature of engaging in homework help as a collaborative activity. In the following paragraphs, we introduce these metrics that address the quality of activity on the part of both students and helpers with the understanding that these are by no means independent.

# 2 Quantitative Metrics

For each thread, we define a *conversation code* that tracks the number of participants, the sequencing of turns, and the number of contributions in an exchange (van de Sande & Leinhardt, 2007). Although these codes do not address conversational content or timing, they provide a means for comparing participation over large numbers of exchanges. For example, the codes reveal how the design and structure of a site influence exchange participation: sites with an AOH structure favor brief exchanges between single student-tutor pairs (low complexity), whereas sites with an SOH structure (and minimal delay for publishing postings) may contain extended exchanges between multiple participants (high complexity).

In addition to highlighting the effects of forum structure on participation, complex conversational codes are positively related to the quality of exchanges, in terms of mathematical depth and pedagogical sophistication (Figure 2). Exchanges with a low complexity are generally communications of sparse fragments of mathematical information (low quality), whereas exchanges with higher complexity may contain elaborated mathematical discussions with sophisticated pedagogical elements (high quality). In exemplary exchanges, mathematical principles are invoked and the problem-solving activity contains valued elements of instructional practice (such as Socratic dialogue).

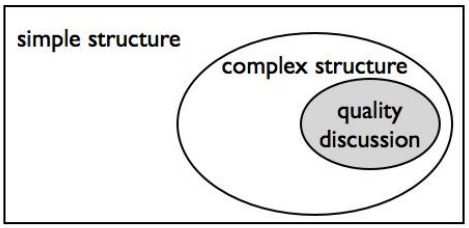


Figure 2. Relationship between quality of discussion and conversation "complexity."

Another quantitative assessment of quality involves timing. Because students are using the forums for homework help and have assignments that are due,

successful forums provide quick responses to student queries. We define *response latency* to be the time from initial student post to first response. For more successful forums, the response latency can be a few hours or as low as thirty minutes.

# 3 Student Activity

Clearly, if a forum is affording collaborative opportunities rather than serving as a cheat site, then this should be evident from qualitative analyses of student contributions. Three markers of student activity, grounded in research on face-to-face interaction (Greeno, 2006), are the presence of assertions and proposals for mathematical actions, questions and challenges of others' proposals, and indicators of resolution (van de Sande, 2008). In terms of making assertions and proposals for action, there are two locations within each thread in which a student has opportunity to contribute to the construction of the solution to the problem: the initial post and in post(s) following helper intervention. Thus, there are four descriptive characterizations of student activity: coasting (absence of assertions), slacking (assertions in initial post), ramping (assertions following intervention), and sustaining (assertions throughout) (van de Sande, 2010). In terms of establishing common ground, students may either accept or question the contributions of helpers (Clark, 1996) to establish mutual understanding. Questioning may be part of a self-regulatory learning strategy to repair knowledge deficits. Finally, students initiate forum exchanges and are therefore positioned to initiate resolution (specifying if and how the exchange was helpful). This can take be done in either a weak (unsubstantiated) or strong (reflective) manner.

# 4 Helper Activity

One can also examine the nature of helpers' contributions in the exchanges. Helpers can adopt various pedagogical strategies, ranging from providing (partial) worked solutions to initiating a dialogue. The choice of strategy sets the tone for the ensuing exchange with the student in terms of expectations and, more generally, instantiates community norms for help seeking (Nelson-Le Gall, 1985). In addition to interacting with students, helpers in some forums exhibit a strong sense of community (van de Sande & Leinhardt, 2007). For example, they share explicit and implicit goals, identify themselves as members of the community, and assume shared responsibility for participation. SOH forums afford opportunities for members to interact with one another that are manifest in distinctive patterns of participation. In order to describe these patterns of participation, it is useful to view forum helpers as "Good Samaritans," who come to the aid of students in mathematical distress (van de Sande & Leinhardt, 2008). For instance, there is a

sense in which help becomes contagious as proposed solutions or perspectives on a problem prompt other forum helpers to contribute their ideas with the goal of improving and augmenting the discussion. There are three ways that helpers contribute to the quality of help as a collaborative activity: bringing mathematical practices to life, fostering alternative perspectives, and supporting mathematical accuracy (van de Sande, 2008).

# 5 An example

Table I is a reconstruction of a thread that shows what activity on an open, online, mathematics help forum can look like. This thread was taken from www.maths-forum.com, a French site, and involves a student (Tomi) and three helpers (Erico, Dan314, and Scare) discussing polynomial factorization and division. In order to protect the identity of forum participants, names have been altered in this paper.

| **Posted by** [member] **at** [time] | **Text** |
|---|---|
| **Tomi @** 12h09  | **Polynôme de degré 3**<br><br>Bonjours à toutes & tous,<br><br>J'ai un problème sur une question d'un exercice,<br><br>**Question de l'exo :**<br>On considère le polynôme $P(x)=2x^3+3x^2-5$.<br>Calculer $P(1)$.<br>En déduire une factorisation de $P(x)$ et le signe de $P(x)$ suivant les valeurs de $x$.<br>**Mes résultats :**<br>Évidemment je trouve $P(1)=0$.<br>Mais ensuite je bloque complètement, je ne comprend pas le système de division pour $\frac{2x^3+3x^2-5}{x-1}$.<br>J'ai cherché et trouvé des méthodes que je n'est jamais étudié en classe bizarrement. On parle de soit faire une division du type : $\frac{2x^3+3x^2-5}{x-1}$ ou alors procédé par division synthétique, mais dans les deux cas je reste à coter de la plaque. J'ai cru comprendre que la division synthétique est plus simple, j'ai donc cherché à procédé par division synthétique mais, impossible pour moi de comprendre sont fonctionnement.<br>=>Si quelqu'un pourrait m'éclaircir tout ça, je le remercie d'avance. |

| | |
|---|---|
| | Tomi.<br>_____<br>... => => => => => => => => !! |
| **Erico** @ 12h13 | il te suffit de mettre (x-1) en facteur dans $2x^3+3x^2-5$<br>tu as plein de façons de faire ça. Soit directement en déduisant chaque terme, la division euclidienne des polynômes ou bien si tu ne sais pas tu poses $2x^3+3x^2-5 = (x-1)(2x^2+ax+b)$<br>tu développes le second membre et tu identifies chaque terme avec le membre de gauche<br><br>(pour la division euclidienne regardes wikipedia : ici ) |
| **Dan314** @ 12h19  | Salut,<br>Si t'est vraiment flemmard (ce qui est une trés bonne chose pour un matheux), tu peut même constater que, de la même façon qu'Ericovitchi a directement mis un '2' devant le $x^2$ pour que, quand on le multiplie par le 'x' du premier terme on obtienne bien le 2x^3 désiré, on peut directement mettre un 5 à la place du 'b' pour que, quand on le multiplie par le -1 du premier terme, ça fasse bien le -5 désiré.<br>Il ne reste donc que le 'a' à trouver... |
| **Tomi @** 12h26  | Tout d'abord merci de ta réponse,<br><br>J'ai donc procédé de la manière suivante :<br><br>$2x^3+3x^2-5=(x-1)(2x^2+ax+b)=2x^3+ax^2+bx-2x^2-ax-b=2x^3+(a-2)x^2+(b-a)x-b$<br><br>Et par identification des termes j'obtiens :<br>$\begin{cases} a-2=3 \\ b=5 \end{cases}$<br>$\begin{cases} a=5 \\ b=5 \end{cases}$<br><br>Donc la forme factoriser de $P(x)$ est:<br>$P(x)=(x-1)(2x^2+5x+5)$<br><br>Est-ce bien ça ?<br>Merci.<br>_____<br>... => => => => => => => => !! |
| **Tomi @** 12h36 | Bonjour Dan,<br>Citation: |

| | |
|---|---|
|  | Posté par **Dan314**<br>*Si t'est vraiment flemmard*<br>tout à fait ,<br><br>J'approuve totalement ton supplément, mais du faite que cette année j'ai changé pour la 5ème fois de prof de math..., j'ai une nouvelle prof depuis 2 semaines et donc je préfère faire tout point par point de peur que la méthode dite "flémarde" ne lui convienne pas ne sachant pas sa façon exacte de fonctionné.<br>Je te remercie de ta réponse.<br>Tomi.<br>_____<br>... => => => => => => => => => !! |
| **Tomi @** 13h21<br>  | Un petit up pour me confirmer la réponse svp<br>_____<br>... => => => => => => => => => !! |
| **Scare** @13h24 | Salut !<br><br>La factorization est bonne |
| **Tomi @** 13h24<br>  | merci beaucoup !<br>_____<br>... => => => => => => => => => !! |

Table I. Reconstruction of thread on polynomial factorization and division from French mathematics SOH site.

This thread, titled Polynôme de degré 3, has a relatively complex conversation code of 12311141, where each 1 in the code represents a contribution from Tomi and subsequent numbers represent contributions from the three helpers (2 for Erico, 3 for Dan314, and 4 for Scare). From this code, we can see that the student remains a contributor throughout the thread, and that the three helpers appear to be working cooperatively with Tomi. The timing also reveals a tight-knit help-seeking interaction. The response latency is only 4 minutes and all of the interaction takes place within 1.25 hours.

In terms of student activity, we see that Tomi contributes initially to the construction of the solution by showing the work done on the exercise (Row 1 of

Table I) and following helper intervention (Row 4). Tomi also shares details of her/his classroom experience with the forum (Row 5), indicating that the collaborative activity embedded in the forum extends beyond the purely cognitive. We also see this in the sequence of emoticons that is Tomi's signature (Rows 1, 4-6, and 8): learning (head in book) leading to impasse (head banging on brick wall) and frustration (tears) that is gradually transformed to understanding (wide eyes), happiness (smiles), and victory (thumbs up!).

In terms of helper activity, we see how three helpers cooperatively work to support Tomi. In a manifestation of cumulative thinking (Baker, 2010), Erico, the first to respond, does not give a solution but suggests and outlines an alternative method to what Tomi suggested, while at the same time providing an external reference if Tomi wished to pursue her/his line of thought (Row 2). When the second helper enters, we see extensional activity (Row 3) together with the way in which mathematical dispositions of study (here, laziness) can enter naturally into the flow of forum experience. The third helper, Scare, contributes by verifying Tomi's work (Row 7) and thereby alleviating the built up tension (Row 6) from waiting for a response. The final contribution from Tomi (Row 8) demonstrates closure; the problem has been resolved and the interaction helpful.

# 6 Conclusions

By identifying features of 'good' and 'bad' forum threads, we are better positioned to help students and helpers effectively work together as students seek homework help outside of the classroom and helpers seek communities of practice. The CSCL community has recognized the importance of connecting measures of quality to concrete learning gains. Thus, for this research, future work includes refining assessments of quality, followed by relating the nature of forum interactions to student learning outcomes.

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