

Ask Dr. Math: The Tenure Process

Ian Underwood, Steve Weimar, Robert Rider,
Thomas Hewett, Bruce Char, Jeremy Johnson
and Werner Krandick

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Department of Computer Science
Drexel University
Philadelphia, PA 19104
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Ian Underwood

Steve Weimar

The MathForum
School of Education
Drexel University

Robert Rider

Thomas Hewett

Department of Psychology and Department of Computer Science
Drexel University

Bruce Char

Jeremy Johnson

Werner Krandick

Department of Computer Science
Drexel University

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Authors' contact: Robert Rider, Department of Psychology, Drexel University,
Philadelphia, PA 19104 rlr32@drexel.edu

Introduction

Ask Dr. Math is a free mathematics help service provided to the public by the Math Forum @ Drexel University (www.mathforum.org/dr.math). The overarching mission of Ask Dr. Math is to provide a functional question and answer service for math students and their teachers, as well as other individuals who are encountering difficulty related to mathematics. Ask Dr. Math offers help in the form of one-on-one correspondence with a math expert (Math Doctor). The Math Doctors are volunteers from the community who offer their time and knowledge to the public via the Ask Dr. Math service. Their expertise in answering mathematics questions is of particular interest to cognitive psychologists who study expertise and problem solving. Currently the volunteers are evaluated and trained by a service administrator (SA), with extensive experience in this capacity. The SA is also an experienced and currently practicing Math Doctor himself.

Generally, in order to become a full-fledged Math Doctor, a new volunteer (candidate) must demonstrate proficiencies in the following five domains:

1. **Knowledge of math concepts:** Demonstrating a thorough understanding of math facts and operations in one or more areas of specialty.
2. **Generating cogent responses:** The ability to write clearly, yet conversationally.
3. **Self-criticism:** The ability to apply a critical perspective to one's responses and actively try to misunderstand one's own response.

4. **Accuracy and precision:** The “habit of correctness” in writing, computation, and answer formulation.
5. **Diagnostic skill:** The ability to recognize the underlying problem in the student’s understanding as opposed the treating the “symptoms” or the manifestations of the underlying problem as they appear in the patient’s question.

These domains will be discussed further in the ensuing review of the screening and training processes which each new candidate must undergo at Ask Dr. Math. Interviews with the SA were conducted to assess the current training process, beginning with the candidate’s response to an initial sample problem, and ending with the status of “tenure”, which allows the candidate full Math Doctor status that entails permission to operate and answer questions independently. The following information was gathered from the interview and from observations of Math Doctor activities by the author over the course of one year. These observations included both looking at email exchanges between the SA and candidate Math Doctors and the author registering for and undergoing some of the same training exercises as do candidate Math Doctors.

The Screening Process

The first task which individuals who volunteer to become Math Doctors must complete is a screening tool that requires answering one of three sample problems. The sample problems were designed to reflect the typical types of problems submitted to the service (see appendix A). The new volunteer’s response to the sample problem is subject to a series of automated self-check

prompts (see appendix B), which the volunteer must use to refine the answer. The final answer to this sample problem is evaluated by the SA based primarily on the five criteria listed in the introduction. Those domains in which the volunteer demonstrates weakness are addressed via an ongoing correspondence with the SA during an individualized training process guided by the SA.

After the candidate sufficiently demonstrates the requisite proficiencies, as subjectively determined by the SA, a the status of Math Doctor with “tenure” is offered, which means that subsequent responses to patients’ questions may be submitted without oversight by the SA.

The Tenure Process

Achieving tenure, or permission to answering questions unmonitored by the SA, begins with the initial sample problem and self-checks. The SA indicated that, while all of the self-check prompts represent important skills for a Math Doctor to have, some are more relevant (are weighted more heavily) than others. Specifically, the SA indicated that Prompt #3: “Did you address the underlying math concepts?” represents the most crucial ability – Diagnostic Skill – for a Math Doctor candidate to demonstrate prior to achieving tenure. Moving beyond simply answering the question for the patient, and instead aiding the patient in answering the question – via a better understanding of the core concepts involved – is the essential focus of the Ask Dr. Math service.

If it is evident to the SA that this “diagnostic skill” is not sufficiently developed in the candidate upon his or her completion of the sample problem,

then the ensuing training period will focus on the skill of distilling the underlying math concepts involved in a patient's question in a way that is understandable to the patient, rather than giving the student the answer or demonstrating a particular computational technique relevant to a single problem.

While the candidate's performance on the self-check prompts is not measured objectively or directly, it serves to inform the SA's decision making process regarding whether or not tenure should be offered. For example, if a candidate answers the simultaneous linear equations sample question (see appendix A, #2), the SA looks for a discussion of what it means for a pair of equations to have a simultaneous solution. With many responses which fail to address the underlying problem, the SA's feedback typically looks like this:

"It's almost certain that the technique you've shown here has already been demonstrated to Curtis, by his math teacher and in his textbook. The question we want to address is this: Why haven't those demonstrations been sinking in?"

The Math Doctor candidate has to assume that the patient has had the "normal" instruction, and thus the presenting difficulty must be addressed in a different way. Knowing how to do that is something that tends to come more from experience with answering questions rather than from an extensive knowledge of mathematics.

In addition, clarity in writing is essential (Appendix B, #8 & #9). The ability to write clear sentences and paragraphs, using grammatically correct, simple English, with good spelling and formatting supersedes other concerns. It is imperative for the candidate to demonstrate this skill, as the SA notes, "because

they're things you learn over the course of a lifetime, so I'm not really in a position to teach them.”

The remaining training prompts represent areas which may be important in training. However, those mentioned above address the most critical issues for tenure, as determined by the SA. As an initial screening/diagnostic tool for candidates, the sample question provides information for the SA which aides in determining the areas of focus for training, and provides some indication of the length of the tenure process. In one interview, the SA noted that “The more of those things they do right the first time, the sooner I expect them to get through tenure.”

When asked if any particular sample question is most predictive of eventual tenure, the SA indicated that each question has its own predictive value. Most candidates choose to answer the simultaneous equations sample question (Appendix A, #2). The goal for this question is to help the patient understand *what* to solve and *why*. Many focus on simply showing what to do, not how to understand the underlying principle involved. Responses to the sample question are often indicative of the degree to which the candidate can identify and explain the reasons for the underlying problem (diagnosing the “illness”) as opposed to simply trying to remediate the problem by showing how to solve this particular set of equations (treating the “symptoms”). Further, answers to this question typically generate some ambiguity as to the abilities of the candidate.

Similarly, Question #1, which asks why decimal places need to be aligned in addition and subtraction, but not in multiplication and division (see Appendix A,

#1) gets at how well a candidate can “diagnose the illness”. However, the SA indicated that candidate’s answers on this item tend to be “hit or miss”. In other words, the candidate either provides a satisfactory answer, or fails completely.

The third question, dealing with adding fractions (Appendix A, #3), is intended to be somewhat deceptive. The candidate must discover that the teacher has not realized that the patient is not getting the wrong answer. Instead, the patient is having trouble understanding the underlying principle of adding fractions.

Training

Following the initial sample problem, the SA noted that there are three “very informal” criteria, or milestones, which determine a volunteer candidate's readiness for tenure:

1. The candidate should answer about 10-12 consecutive answers with no changes or revisions.
2. The candidate must demonstrate some familiarity with the archive and Frequently Asked Questions sections, as evidenced by the use of citations, so he can cite those resources effectively.
3. The candidate must exhibit a capability for answering a range of questions, and an understanding of what his or her range is. The SA indicated that there is no particular piece of information that definitively indicates this, but that it is based on a “feeling” he gets after reading a number of the candidates responses.

During the training period, there are three potential results for every answer sent out by the Math Doctor candidate:

1. The answer is sent out “as is”, if there are no changes needed.
2. The answer sent out with changes made by the SA. An email is also sent to the candidate so they can look at the differences between their answer and the final product. This option may be taken when the corrections needed are too minor to justify delaying the response, or so major that a complete rewrite is called for.
3. The answer is sent back to the candidate and for revision and then re-sent to the patient.

The Service Administrator

The SA was asked how he would train someone to do the work of “tenuring” and training Math Doctor candidates. He noted that, as a service administrator, the goal is essentially the same as that of Math Doctors. In other words, the SA must be able to identify the level of the candidate and “diagnose” any problems with the approach taken to answering patient’s questions. This requires understanding the hallmarks of those proficiencies outlined in the introduction to this report. Essentially, the SA must determine whether the candidate has internalized the self-checks contained in the sample question prompts. The SA noted that one can, “teach without telling”, and this perspective must be engendered in the candidate throughout the training process.

An SA, responsible for screening and training Math Doctor candidates should be able to determine whether a candidate can diagnose the cause and

not just the symptoms. The SA feels that for somebody to know what this looks like in a Math Doctor candidate, it requires experience with the Ask Dr. Math service, a knowledge of the archive, and an understanding of the importance of context (i.e. individuals learn differently at different levels of education). Math Doctor candidates also need to demonstrate knowledge of the limitations of their range, and the SA must be able to identify this also, as well as know what to do when the candidate does not have this sense.

Summary and Conclusions

The volunteers at Ask Dr. Math are expected to demonstrate several important abilities prior to being given permission to operate independently, i.e., without oversight. The current screening process is composed of a single response to a sample question that is first subject to self-check prompts, and then to scoring by the service administrator. The volunteer is then trained, based on this initial sample problem and subsequent answers to actual student's questions. Once the volunteer refines his or her skills, and demonstrates the requisite knowledge of math concepts, ability to generate cogent responses, a high level of self-criticism, accuracy and precision, and diagnostic skill, the status of tenure is offered and the new Math Doctor is then allowed to answer questions without supervision.

Currently, the decision making process at each stage – screening, training, and offering tenure, requires the expertise of an experienced SA who has a firm grasp on the proficiencies necessary for a candidate to operate independently. In addition, an SA must have familiarity with the Ask Dr. Math

service. However, a standardized screening approach could engender greater efficiency to the training process and expedite tenure, while opening up the possibility of training new SA's more readily.

Using an empirically-based scoring system during the screening phase of Math Doctor training to provide an idiosyncratic "diagnosis" of the Math Doctor candidate's strengths and weaknesses could allow for the development of a "treatment plan" to focus training on the most essential weaknesses and build upon the existing strengths. Furthermore, the information gathered in the screening could provide evidence of the candidate's strengths, and area of specialty, to assign specific question types to that candidate and increase the overall output and efficiency of the service.

While a regimented course has, in the past, been unsuccessful, a more candidate-specific training approach may decrease the demands on the SA and allow for a greater number of volunteers to advance from application to tenure. The reader is referred to technical report DU-CS-06-03 for a discussion of one potential model for a standardized screening tool for Math Doctor candidates, which draws on research in the field of teaching expertise.

Appendix A

Introduction and Sample Problems

Ask Dr. Math: Becoming a Volunteer 'Math Doctor'

The Math Forum's Ask Dr. Math service provides a place for people who want to share their knowledge of math with people who need help learning math.

It is *not* a 'homework help' service. As a general rule, we don't provide 'answers' to the questions that we get. Rather, we try to help our 'patients' get the insight they need to answer their *own* questions.

The first step toward becoming a 'math doctor' is to try your hand at answering a typical question, assisted by an online 'guide' that we've put together to help you evaluate (and possibly revise) your answer as you write it, as well as to explain some of the philosophy behind our approach to answering questions. This will give you a feel for what it's like to try to mentor someone via email, and help you decide whether this is something you think you'd enjoy doing.

If that works out, we'll set you up with an account, and you'll start answering live questions as they come in. Your answers will be reviewed, and you may be required to revise them one or more times before they can be sent out. When we get to the point where we're routinely sending your answers without comment, you'll be cleared to send them directly to the patients.

Does this sound like something you'd like to try? If so, scroll down to the form, choose a question to answer, provide your name and email address, and click the button to get started!

Which question would you like to answer?

#1 From Kay (age 11)

Why do we have to line up decimals when we add and subtract, but not when we multiply and divide?

SA#2 From Curtis (age 16)

**we r doing 2 equations, like
 $2x - 3y = 12$
 $5x + 4y = 7$**

but i can't even solve 1 of them. how am i supposed to solve 2 at once?

#3 From Brent (age 24)

One of my students asked me why, when adding fractions, we can't just add the numerators and denominators, and he used this as his example: "In the first game of a double-header, Joe gets 1 hit in 3 at bats. In the second game, he gets 2 hits in 5 at bats. That's 3 hits in 8 at bats, and $1/3 + 2/5 = 3/8$."

I know this isn't right, but I'm not sure how to explain why.

Help!

Appendix B

Self-Check Prompts

1. Did you address the question that was asked?
2. Did you start from where the patient is?
3. Did you address the underlying math concepts?
4. Would a diagram or graph be helpful?
5. Did you leave some work for the patient to do?
6. Is your math correct?
7. Do you need to explain any notation or terms that you used?
8. Is your English correct?
9. Is your formatting neat and readable?
10. Is your tone friendly and conversational?
11. Is the length and level of your reply appropriate?
12. Did you greet the patient by name?
13. Did you end in a way that invites continued conversation?
14. Did you have fun? Did it show?

[Note that each prompt is accompanied by a longer explanation, often including examples.]