Asking Great Questions: Part of a Theory of Communication in Interdisciplinary Collaborations

Eric A. Vance[1] and Heather S. Smith[2]
[1]Laboratory for Interdisciplinary Statistical Analysis, University of Colorado Boulder, USA, Eric.Vance@Colorado.EDU
[2]Department of Statistics, Cal Poly, San Luis Obispo, CA, USA

ABSTRACT
The questions we ask and the way in which we ask them can make all the difference in how successful we are in meetings, in collaborations, and in our careers as statisticians and data scientists. What makes a question good and what makes a good question great? In this paper, we develop a theory for asking great questions that elicit information useful for accomplishing the tasks of a collaborative project and also strengthen the statistician-domain expert relationship. We deconstruct asking great questions into three parts: the question, the answer, and the paraphrasing of the answer to create shared understanding. We discuss three strategies for asking great questions: preface questions with statements about the intent behind asking the question, follow the question with behaviors and actions consistent with the prefaced words including actions such as listening, paraphrasing, and summarizing; and model a collaborative relationship via the asking of a great question. We provide practical guidelines for learning these skills so that statisticians can improve their statistical collaboration skills and thus increase their impact to help address societal challenges.

Key Words: statistical consulting, statistical collaboration, statistical practice, statistics education, data science, shared understanding

1. INTRODUCTION
Statisticians and data scientists rarely collect the data they analyze, nor do they typically originate the research, business, and policy questions they help answer. Therefore, applied statisticians and data scientists must routinely collaborate with domain experts who have collected or will collect data to help them answer questions from their domain. Complicating efforts to solve interdisciplinary problems is that communication between statisticians and scientists is a serious problem (Hoadley and Kettenring 1990), partly because the statisticians do not fully understand the problems they are trying to solve (Kimball 1957). Industry, government, and academia increasingly demand that the statisticians they hire can effectively interact with non-statisticians (Geller 2011). For many statisticians, inadequacy in communication skills inhibits their ability to make a positive impact on society. Statisticians need to become proficient in essential communication and collaboration skills so that they may effectively collaborate with domain experts to make discoveries and create innovations and ultimately to transform evidence into action (Olubusoye et al. 2021) that will help societies develop and improve the lives of people worldwide (Vance and Love 2021).

To help overcome the challenges of communication, the literature on statistical consulting and collaboration is filled with advice for statisticians to ask *good* questions. Kimball (1957) states that asking good questions can help prevent the commission of Type III errors (i.e., providing the right answer to the wrong question). Lurie (1958) writes that a statistician has the responsibility to ask scientists three “impertinent”

questions about their specific hypotheses, how broad or narrow the model and scope of inference will be, and the level of statistical significance the scientist cares about. Lurie suggests statisticians provide the reasons for asking these questions, to make them seem to the scientist less impertinent. Lurie's three questions are:

1. With respect to the experiment you are performing, just what are your ideas?
2. With respect to the scientific area to which these ideas refer, just what are they about?
3. How sure do you want to be of the correctness of these ideas?

Hand (1994) discusses methods for mapping the domain expert's research questions to statistical techniques, a task which he considers more difficult than establishing the mathematical properties of statistical techniques. He calls for more research into the topic of "asking good questions" and writes: "We might also argue that establishing a valid such mapping is more important than applying rigorous mathematics to the problem formulation which results: it is better to have an approximation (if we know that it is an approximation) to the question that we want to ask, than to have a mathematically correct solution to an irrelevant question" (1994, p. 336). Lehoczky (1995, p. 13) states: "I believe that the most important statistical skill in cross-disciplinary investigations involves structuring the questions to be asked and developing the methods of inquiry as opposed to being able to pull an especially appropriate statistical procedure off the shelf."

In Derr's chapter on "Asking Good Questions" (2000, chap. 5), she asserts that statistical problem-solving begins with questions. The statistician needs to know what questions to ask and how to ask them to get accurate and complete information about the domain expert's problem and the statistical issues in their field. With that information, the statistician can identify the domain problem to be solved and then translate that into an appropriate statistical model. Completing this process of statistical problem-solving, the statistician will develop a statistical solution based on the model and then translate a recommendation back to the domain expert in language that she can understand, accept, and apply to her problem.

Similarly, Vance et al. (2020) advise statisticians to ask domain experts questions that will 1) probe domain experts to improve the domain experts' understanding of their own research questions, 2) advance the domain experts' understanding of the statistical analyses that will answer these questions, 3) gather information to improve the statistician's understanding of the domain problem, and 4) improve the statistician's understanding of the statistical issues to enable the statistician to develop appropriate analyses that will answer the domain questions. Most recently, Sharp et al. (2021) produced ten videos to help students learn statistical collaboration and specifically to demonstrate the power of asking good questions.

Building upon this literature, we believe that every statistician can improve their statistical collaboration skills and thereby increase their potential to help address societal challenges. This article provides a framework for asking *great* questions and how to implement it in practice. Section 2 explains what makes a question good and what makes a good question *great*. Section 3 deconstructs great questions into questions, answers, and the paraphrasing of the answer to create shared understanding. In Section 4 we provide strategies for how to ask great questions in practice and illustrate these strategies with examples. Section 5 discusses how this framework for asking great questions can improve the practice of statistics and data science. Section 6 concludes this paper.

2. WHAT IS A *GREAT* QUESTION?

Derr (2000) characterizes *good* questions for statisticians to ask as those that help the statistician identify an appropriate scientific question and then translate the scientific question into a scientific model, the scientific model into a statistical model, and the statistical model into an answer to the scientific question. In other words, a *good question* elicits the information necessary to provide a correct answer to the right scientific question. Derr's model for asking good questions has three parts:

1. Ask questions to avoid making a Type III error of "providing the right answer to the wrong problem" as described by Kimball (1957).
2. Identify what one needs to find out from the domain expert. Specifically: What type of investigation is this (designed experiment, sample survey, or observational study)? At what stage is this investigation (planning or analysis stage)? What limits and constraints govern the study (i.e., ask questions to become familiar with typical statistical issues that arise in the domain expert's field of study)?
3. Develop an effective strategy for gathering information, which means: A. Avoid poor communication strategies such as asking jargon-filled closed questions or leading questions and B. Adopt more effective communication strategies such as using closed probes to get specific information, using open probes to get general information, using concrete paraphrasing to clarify one's understanding, and integrating both open and closed probes to get the general and specific information needed to be able to translate the domain expert's problem into a statistical model.

In the context of teaching statistics, we paraphrase Rossman (2010, 2021) to say that a *good question* leads students to improve their understanding of statistics AND results in the instructor better understanding how well the students have learned.

In our theory of collaboration (Vance and Smith 2019), we identify *task* and *relationship* as the two parts of every collaboration. Vance (2020) expands on this by making the case that there are two terminal or end goals for every collaboration: making a deep contribution and creating a strong relationship. Applying this theory to asking questions, a ***good question*** elicits information necessary to successfully accomplish the *tasks* of the project toward making a deep contribution OR strengthens the *relationship* between the statistician and domain expert. A *great* question does both.

A ***great question*** *elicits information necessary* to successfully accomplish the tasks of the project AND *strengthens the relationship* between the statistician and domain expert.

An analogy to help explain this concept: A great question accomplishes two goals simultaneously, like when a parent reads a child a bedtime story. Reading helps improve the child's cognitive skills (task) while strengthening the parent-child bond (relationship). Similarly, a great question improves a statistician's ability to do a good job and strengthens their relationship with the domain expert.

For example, in a collaboration between a statistician and a domain expert, the statistician can ask, "I have learned that I make the most valuable contributions to a project when I understand both what you want to do and also why you want to do it. To help me understand I propose that I ask you some questions and we discuss until you feel that I understand your project. Will that work for you?

- What is your overall scientific question?

- Why is that important?
- If that question gets answered, what happens next?
- Why is that important?"

This series of questions will elicit information about the domain problem helpful to make expert statistical decisions and is asked in a way that will strengthen the relationship with the domain expert.

Figure 1 shows where questions can be in the space defined by two dimensions: to what degree a question strengthens or weakens a relationship (y-axis) and how well it elicits information necessary toward accomplishing the task (x-axis). Great questions in quadrant I are high along both axes. Good questions are strong on just one axis. OK questions lie in quadrants II and IV such as the impertinent questions suggested by Lurie (1958) that may elicit important information to accomplish the task but at the expense of weakening the relationship. Bad questions in quadrant III weaken relationships and derail progress toward making a deep contribution.

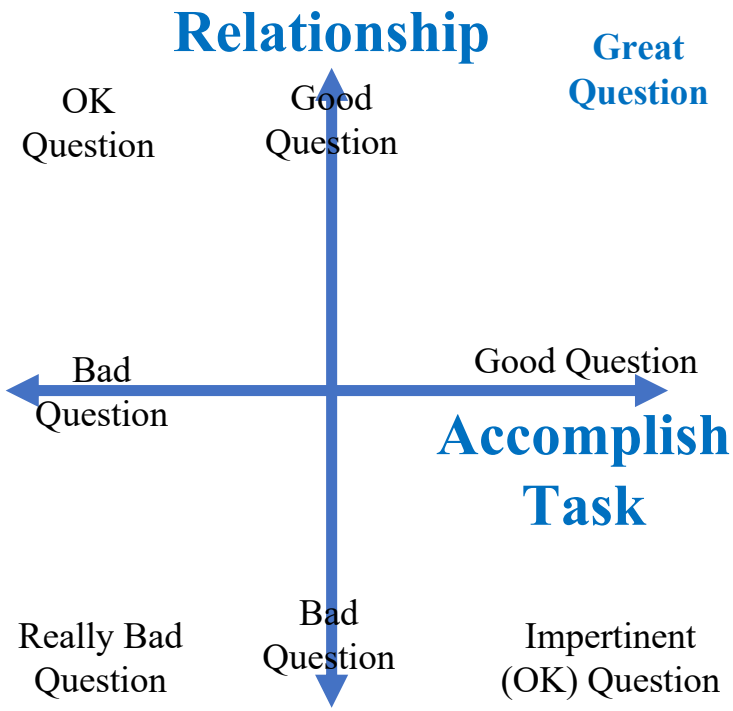

Figure 1: The degree of relationship building or progress toward accomplishing the task determine how bad, good, or great a question is. Great questions help accomplish the task and strengthen the relationship.

Technical definition: A *great question* in statistical collaborations accomplishes two aims: 1) The question elicits information useful for answering the domain research/business/policy questions and 2) The question is asked in a way that strengthens the relationship with the domain expert. In Section 4 we provide strategies for asking great questions and examples.

3. DECONSTRUCTING GREAT QUESTIONS

Great questions have three components: the question, the answer, and the paraphrasing of the answer to create shared understanding, which Vance et al. (in press) describe as occurring when the statistician and domain expert have a common interpretation of a

concept, fact, or idea (i.e., the answer to a great question) and its relevance for the project. The question itself can strengthen the relationship. The answer can provide useful information for accomplishing the task. Paraphrasing and summarizing the answer creates shared understanding, which is useful for both accomplishing the task and strengthening the relationship (Vance et al. in press). Altogether, great questions help statisticians make deep contributions to projects and strengthen their relationships, which are the two end goals of a collaboration (Vance 2020).

3.1 The Question

The question a statistician asks a domain expert can strengthen their relationship along four dimensions: alignment of goals, amount of co-creation, the nature of the relationship, and time and attention. We briefly discuss these four dimensions and provide examples of great questions (**in bold**).

3.1.1 Alignment of goals

Having shared goals for a project strengthens professional relationships. Statisticians can ask questions that highlight the goals they share with the domain expert and emphasize their commonalities. For example, **"My goal for this initial meeting is to understand your research questions, which will help me think about the specific statistical issues. What would you like to accomplish in this meeting?"** Another example is, **"I want to make sure that the analyses I perform will be useful, so how will you be using the results? What is the final product you will be submitting?"**

Questions can also help to clarify expectations between both parties. Disappointments resulting from differing expectations weaken relationships. Therefore, asking questions that clarify expectations can lead to stronger relationships. For example, **"The guidelines for my field state that if I do the statistical analyses and write up the statistical methods, I must be a co-author on the resulting manuscript** (International Committee of Medical Journal Editors 2021)**. On the other hand, if you don't think co-authorship is a viable option, I could just provide advice to you today on which statistical methods I think may be appropriate. What role for me on this project would you prefer?"**

3.1.2 Amount of co-creation

Parties that perceive themselves as members of a team often report stronger relationships with each other. Similarly, those who perceive themselves on a journey or adventure together with other parties to discover new things also report strong relationships. Questions that imply working as a team can help achieve this. For example, using "we" instead of "you" or "I". For example, **"Am I understanding correctly? We want to determine how X affects Y in the presence of Z?"** instead of, "You want to know how X affects Y in the presence of Z?" Similarly, **"What can I clarify about our results?"** can lead to a stronger relationship than, "What else would you like to know about my analysis?"

In our experience, however, the best way to co-create knowledge toward the achievement of a shared goal is to create shared understanding about the underlying facts and information about the project by paraphrasing the answer to a great question and then summarizing its relevance toward achieving the project's goals (Vance et al. in press). We discuss this further in subsection 3.3.

3.1.3 The nature of the relationship
Ridd et al. (2009) describe strong patient-doctor relationships as those featuring high levels of trust, regard (i.e., liking and respect), and loyalty. Statisticians can ask questions to improve these aspects of their relationships with domain experts. For example, **"On past projects I have done [such and such]. Would you like me to do that for this project?"**; **"Your research sounds so interesting. Can you tell me more?"**; **"I can definitely do that for you. What else would you like me to do?"** or **"I will prioritize doing this for you. By when will you need a report of what I've done?"**

The way in which the question is asked (i.e., the nonverbal aspects of the question such as tone, volume, facial expressions) can be more important that the actual content of the question, but this is beyond the scope of this paper.

3.1.4 Time and attention
Cultivating relationships takes time and attention. In our experience, "glue" questions that explicitly check for understanding and attend to the relationship are effective in strengthening the relationship. For example, **"What can I clarify?"** or **"Just so we're on the same page, is my understanding correct that each animal is provided four different feed types?"** or "**How does this meeting time generally work for you?"** or **"Is there anything we should change to make our future meetings more productive?"**

In addition, questions asked via email/chat/phone between meetings can keep both the statistician and domain expert engaged in the project, prevent feelings that the domain expert is a low priority for the statistician, and strengthen the relationship. For a statistician working on many projects, when she thinks about one of the projects, if she has not met with the domain expert on that project recently, sending a quick email to inquire about the status of the project can help keep the relationship strong. For example, emailing, **"Just checking in, is there anything you need from me to advance this project?"**

3.2 The Answer

The answers to great questions provide statisticians with the information necessary to successfully accomplish the task of the project. To get these answers, Derr (2000) describes the difference between open-ended questions and closed questions and the importance for statisticians to employ both when interacting with a domain expert. Open-ended questions are most effective for obtaining a broad understanding of the major features of the domain problem. Examples from Derr (2000, p. 85) include: "How did you assign the test diets to the animals?" and "What factors are likely to affect the subject's response to treatment?" These open-ended questions may provide the statistician with exactly the answers she needs. On the other hand, these types of questions may elicit vague answers that require specific follow-up questions.

Closed questions (i.e., Yes/No questions or forced choice questions) are useful for obtaining specific information, as long as they are clearly worded and free from jargon. Examples from Derr (2000, p. 84) include: "Can the animals interact with each other?" and "Are you able to change the order in which different animals receive the treatment or must the order be the same for each animal?"

In our experience, mixing open-ended questions to obtain broad understanding and closed questions to elicit specific information is an excellent way to obtain information about the domain problem and its context and the statistical issues specific to that problem.

However, when asking closed questions, the statistician must be cognizant of the potential for a version of confirmation bias called *positive test strategy* (Klayman 1995; Klayman and Ha 1987), which is a tendency of the statistician to test an internal hypothesis or assumption by asking the domain expert about instances where the target property is hypothesized or known to be present. In other words, people in general tend to ask closed questions in which an answer of, "Yes" would provide evidence in favor of the underlying hypothesis or assumption. For example, if a statistician expects that subjects *should* be assigned treatments at random, she might ask a closed question, "Were the treatments assigned randomly to the subjects?", in which the expected and socially desirable answer is, "Yes."

Zuckerman, et al. (1995) found that when a positive test strategy is combined with the tendency of the person being asked questions to *acquiesce* or provide a socially desirable answer—i.e., provide a "Yes" answer to a Yes/No question—resulting inferences are biased toward confirming the hypothesis or assumption being tested. They found that confirmation of a hypothesis or assumption can be the result of the types of questions asked and the kind of answers given. In other words, if statisticians ask questions to which they expect a "Yes" answer, and if domain experts are more likely to answer, "Yes" to a Yes/No closed question, statisticians may propose statistical methods based on an incorrect understanding of the underlying problem.

To counter the tendency of domain experts to answer "Yes" more often than they should and that bias potentially leading the statistician down a wrong path, we recommend sprinkling in a few closed questions in which the more likely answer (according to the statistician's prior beliefs) is "No." In other words, we recommend occasionally asking about the opposite of what is expected or socially desirable. For example, **"So I can better understand the experiment, were the first ten subjects to enroll in the study assigned to Treatment A and then the next ten to Treatment B?"** Eliciting "No" answers can help the statistician test her assumptions and eliminate possibilities, thus generating information necessary to successfully accomplish the task of the project.

3.3 Paraphrasing the Answer

Paraphrasing the answer to a question is an impactful component of asking great questions because it helps achieve both aims of great questions: eliciting information necessary to successfully accomplish the tasks of the project and strengthening the relationship between the statistician and domain expert. According to the model of communication within collaboration by Vance et al. (in press), the goal of listening, paraphrasing, and summarizing is to *create shared understanding*, which happens when both statistician and domain expert have a common interpretation of a concept or idea (i.e., they each know that the other knows it as well) and they all know the relevance of the concept to the goals of the project. In other words, ask questions to elicit information necessary to successfully accomplish the tasks of the project; then listen, paraphrase, and summarize to create shared understanding.

For example, the statistician might ask, **"How were the test diets assigned to the animals?"** and then paraphrase the answer in her own words while also phrasing it as a question to check her understanding: **"So, to make sure I understand, the diets were not randomly assigned to each cow, but rather the first ten cows to enter the pen were given Diet A and the next ten cows got Diet B?"** Following up with a summary that explains how this information can be useful to determine the best statistical methods can help the domain expert learn statistics and thereby strengthen the relationship and improve the potential outcomes of the project.

Statisticians who successfully paraphrase such that both parties know without any doubt that they share a common understanding of a concept or idea are better equipped to apply accurate statistical representations to the domain experts' problems (Hand 1994), avoid Type III errors (Kimball 1957), and become stronger collaborators (Ellenberg 2000). Furthermore, when knowledge is created together through the back and forth of questioning, listening, paraphrasing, and summarizing, the relationship is strengthened. For these reasons, questions whose answers are paraphrased to create shared understanding are great questions.

4. STRATEGIES FOR ASKING GREAT QUESTIONS

In this section, we discuss three strategies for transforming good questions that elicit useful information into great questions that also strengthen the relationship. We provide examples (**in bold**) to help the reader may decide how and when to use each strategy in practice.

4.1 Preface Questions with Their Intent

To help strengthen the relationship with the domain expert and get more useful information, briefly explain *why* one is asking the question. In other words, we recommend prefacing a question with statements clarifying the statistician's intention behind asking the question. For example, instead of just asking "How did you assign the test diets to the animals?", preface the question with an explanation of why the answer will be important for achieving your shared goals. A great question would be: **"The statistical models we will use to compare the effectiveness of the animal diets depend on details of the experiment, and I want to be sure I use the most appropriate model. So how did you assign the test diets to the animals?"**

An analogy is how a nurse may state what she will do to the patient before she does it. For example, before injecting a patient with a flu shot, she may state her intent, "I'm going to wipe the area with a disinfectant, which might sting a little, and then I'll give you the shot. Are you ready?" In our experience, prefacing a question with our intent reduces the domain expert's anxiety and improves our relationship.

Prefacing one's intent provides an opportunity for the domain expert to answer an even better, unasked question because he understands the intent of the possibly poorly phrased question. It can transform a series of questions from what may feel like a bombardment to the domain expert (e.g., the impertinent questions described by Lurie (1958)) into a logically flowing conversation whose goal is to provide the statistician with all of the details relevant for creating a statistical model. Derr provides an example of such a conversation (2000, pp. 82–83), which is more pleasant for both statistician and domain expert. It also provides the domain expert information and a window into the statisticians'

thinking. Rather than the statistician always asking questions and being on the receiving end of an information transfer, this strategy makes the process of statistical analysis more transparent and less of a mystery to collaborators.

Sometimes statisticians can ask questions that imply their intent. For example, **"It seems as if your research questions are not completely defined yet. I often see this with people I work with. Would it be useful if I asked you a series of questions to help clarify your options and your goals for your research?"** The implication of the intent behind this question is that the statistician wants to use her experience to be helpful. Such questions that imply an intention to be helpful while clarifying the research questions are great questions.

4.2 Follow up and Follow Through

A second strategy is to follow questions with behaviors and actions consistent with one's words and with one's commitment to building a strong collaborative relationship with the domain expert. Specifically, follow up asking a great question by actively listening and then paraphrasing or summarizing the domain expert's response.

Another aspect of this strategy is to follow up a question with useful options for the domain expert to consider. For example, instead of just asking, **"Can the animals in the experiment interact with each other?"**, follow such a question with further clarification of the intent behind the question and specific options: **"… because if the animals do interact with each other we may to consider how the treatment given to one animal might spillover to another, or if we should consider all of the animals in the pen to be one experimental unit. If there is only minimal interaction, we may be able to model each animal independently."**

Following through on any promises made or implied via one's questions is a sure way to strengthen relationships by establishing trust and creating shared understanding. The inverse—not following through—commonly weakens relationships. Similarly, we recommend pursuing the logical consequences of a domain expert's answer with follow-up questions to create shared understanding of the relevant facts of the project and thereby strengthen the relationship with the domain expert. For example, following up by listening, paraphrasing, and asking another question turns this next question into a great question: **"When running the experiment, did you give each animal the treatment diets in the same order?"** (Domain expert replies, "No.") **"So the animals did not receive the diets in the same chronological order… In what order did each of the animals receive the test diets, because the order might affect how we analyze the data?"**

4.3 Model a Collaborative Relationship

The questions we ask and the ways in which we ask them can demonstrate to the domain expert what type of professional relationship we aspire to have. Do we want a collaborative relationship with the domain expert or a hierarchical one in which the domain expert (or statistician) presumes to be the only expert at the table and in a position to tell the statistician (or domain expert) what to do? To model more collaborative relationships, we recommend phrasing questions as questions—not as statements, demands, declarations, or rhetorical questions that should not be answered.

For example, rather than harshly or accusatorily asking, "You didn't randomize the treatment order, did you?", ask, **"So I can better understand the experiment and model the data, how were the treatments assigned?"**

One component of this strategy is to soften questions that may be considered impertinent. Table 1 shows the three impertinent questions from Lurie (1958) and how they could be improved to model a more collaborative relationship.

Table 1: Examples of making impertinent questions more collaborative

Impertinent Question	Great Question
With respect to the experiment you are performing, just what are your ideas?	**How did you get started on this research and what motivates you about it?**
With respect to the scientific area to which these ideas refer, just what are they about?	**Fascinating! And how will answering these research questions advance your domain?**
How sure do you want to be of the correctness of these ideas?	**The types of analyses we do and how we report results depends on if we are testing hypotheses or exploring the data looking for interesting relationships. So, is this a pre-specified hypothesis you want to test, or would you rather explore what the data say about this?**
	Ultimately, who will be using these results and how? What impacts do you hope they have?

Leman et al. (2015) and Vance and Smith (2019) recommend addressing the Qualitative (Q_1) components of a project before moving on to Quantitative (Q_2) analyses. Vance (2019) lists twelve Q_1 questions for statisticians to ask. In our experience, modeling behaviors we wish to see in the domain expert results in more productive collaborations. Just as statisticians wish to know the motivations behind the domain expert's research/business/policy questions, how the data were collected, and how they will use the results, a domain expert may want to know why a specific statistical technique was used or how a feature of the data collection process impacts the methods applied. By employing strategy 1 and prefacing the intent behind the questions a statistician asks, she is modeling a collaborative relationship by providing the type of information she wants reciprocated from the domain expert. For example, **"Understanding your motivations and your reasons for researching this area helps me get excited about the research and really helps my brain think better statistically. So I'm curious, why do you want to answer this research question?**" is a great question that asks for the domain expert's motivations by providing the statistician's motivations.

4.4 Implement Asking Great Questions in Your Practice of Statistics

Individual statisticians and data scientists from beginners to advanced practitioners can learn how to ask great questions. Here are five steps for doing so:

1. Learn how asking great questions fits into the theory of communication in interdisciplinary collaborations by reading Vance and Smith's article "The ASCCR Framework for Collaboration" (2019). Then read Vance et al.'s article "Creating Shared Understanding in Statistics and Data Science Collaborations"

(in press) for a deep dive into their theory of communication for statistics and data science collaborations.
2. Learn the three strategies described in this paper.
3. Practice asking great questions. Before your next collaboration meeting, write down one or two great questions to ask the domain expert. Turn a question you often ask into a great question. Practice asking these questions out loud in front of a wall, a mirror, a pet, or a role-playing partner.
4. Get feedback on how well you implemented the strategies from your role-playing partner or the actual domain expert. Consider video recording meetings in which you practice asking great questions.
5. Reflect on what went well, what didn't go well, and the impact of asking great questions on your collaborations.

5. RELEVANCE AND DISCUSSION

Vance and Smith (2019) describe statistics and data science collaborations as comprised of five aspects: Attitude, Structure, Content, Communication, and Relationship (the ASCCR Framework, see Figure 2). Focusing on the Communication aspect of the ASCCR Framework, Vance et al. (in press) explain how the goal of communication is to create shared understanding and that this is accomplished by asking great questions; listening, paraphrasing, and summarizing; and effectively explaining statistics to nonstatisticians. They write that it is through effective communication in interdisciplinary collaborations that statisticians and data scientists make deep contributions and create strong relationships, which are the terminal goals of a collaboration (Vance 2020).

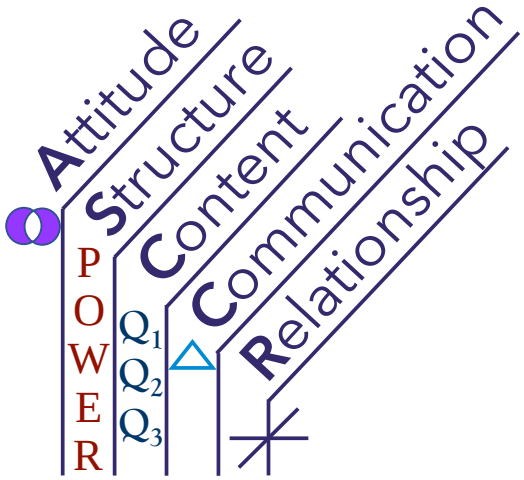

Figure 2: Asking great questions is an element of the Communication component of the ASCCR Framework for collaboration.

We believe that asking great questions can positively impact an individual's practice of collaborative statistics and data science. Intentional focus on the questions statisticians ask will improve their contributions to the fields in which they work and will strengthen their relationships with domain experts. Greater individual impact will mean that the field of statistics will become better appreciated (Halvorsen et al. 2020; Love et al. 2017; Vance 2015) and specifically the area of statistical consulting and collaboration will have greater perceived value (Sharp et al. 2016).

For this to happen at any noticeable scale, the statistics profession needs to teach these methods of communication and collaboration both to current students and to statisticians

on the job. Recent efforts by the American Statistical Association's Committee on Applied Statisticians (Bhattacharyya 2017), the Committee on Career Development, and SPAIG align with this effort to improve the nontechnical skills of statisticians so they can become more effective collaborators.

6. CONCLUSION

The questions we ask and the way in which we ask them can make all the difference in how successful we are in meetings, in collaborations, and in our careers as statisticians and data scientists. In this paper, we explained how a *good* question elicits information necessary to successfully accomplish the tasks of the project toward making a deep contribution or strengthens the relationship between the statistician and domain expert and how a *great* question does both.

A great question can be deconstructed into three parts: the question, the answer, and the paraphrasing of the answer to create shared understanding, and we have provided several examples. By prefacing questions with statements about the intent behind asking the question, following the question with behaviors and actions consistent with the prefaced words (e.g., paraphrasing the answer), and modeling a collaborative relationship, one can turn good questions into great ones. Asking great questions is a skill that can be practiced and developed and can improve a statistician's or data scientist's collaboration skills, thereby increasing their potential impact to help address societal challenges.

ACKNOWLEDGEMENTS

The authors thank their wonderful students and workshop participants who provided feedback on manuscript drafts and examples of asking great questions. This material is based upon work supported by the National Science Foundation under Grant No. 1955109 and Grant No. 2022138 for the projects, "IGE: Transforming the Education and Training of Interdisciplinary Data Scientists (TETRDIS)" and "NRT-HDR: Integrated Data Science (Int dS): Teams for Advancing Bioscience Discovery." This work was also partially supported by the United States Agency for International Development under Cooperative Agreement #7200AA18CA00022.

REFERENCES

Bhattacharyya, A. (2017), "Become a Better Statistician by Actively Collaborating," *Amstat News*, 485, 6.

Derr, J. (2000), *Statistical Consulting: A Guide to Effective Communication*, Pacific Grove, CA: Duxbury Press.

Ellenberg, J. H. (2000), "Communication of statistical concepts: examples in medical collaboration," *Journal of Statistical Computation and Simulation*, 66, 189–207. https://doi.org/10.1080/00949650008812022.

Geller, N. L. (2011), "Statistics: An All-Encompassing Discipline," *Journal of the American Statistical Association*, 106, 1225–1229. https://doi.org/10.1198/jasa.2011.ap11592.

Halvorsen, K. T., Hanford, K. J., Vance, E. A., Wilson, J., and Zahn, D. (2020), "Transforming Your Stumbling Blocks into Stepping Stones," in *JSM Proceedings*, Alexandria, VA: American Statistical Association: Statistical Consulting Section, pp. 2523–2541.

Hand, D. J. (1994), "Deconstructing Statistical Questions," *Journal of the Royal Statistical Society. Series A (Statistics in Society)*, 157, 317–356. https://doi.org/10.2307/2983526.

Hoadley, A. B., and Kettenring, J. R. (1990), "Communications between Statisticians and Engineers/Physical Scientists," *Technometrics*, 32, 243–247. https://doi.org/10.2307/1269092.

International Committee of Medical Journal Editors (2021), "ICMJE | Recommendations | Defining the Role of Authors and Contributors," Available athttp://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html.

Kimball, A. W. (1957), "Errors of the Third Kind in Statistical Consulting," *Journal of the American Statistical Association*, 52, 133–142. https://doi.org/10.2307/2280840.

Klayman, J. (1995), "Varieties of Confirmation Bias," in *Psychology of Learning and Motivation*, eds. J. Busemeyer, R. Hastie, and D. L. Medin, New York: Academic Press, pp. 385–418. https://doi.org/10.1016/S0079-7421(08)60315-1.

Klayman, J., and Ha, Y. (1987), "Confirmation, disconfirmation, and information in hypothesis testing," *Psychological Review*, 94, 211–228. https://doi.org/10.1037/0033-295X.94.2.211.

Lehoczky, J. (1995), "Modernizing Statistics Ph.D. Programs," *The American Statistician*, Taylor & Francis, 49, 12–17. https://doi.org/10.1080/00031305.1995.10476104.

Leman, S., House, L., and Hoegh, A. (2015), "Developing a New Interdisciplinary Computational Analytics Undergraduate Program: A Qualitative-Quantitative-Qualitative Approach," *The American Statistician*, 69, 397–408. https://doi.org/10.1080/00031305.2015.1090337.

Love, K., Vance, E. A., Harrell, F. E., Johnson, D. E., Kutner, M. H., Snee, R. D., and Zahn, D. (2017), "Developing a Career in the Practice of Statistics: The Mentor's Perspective," *The American Statistician*, 71, 38–46. https://doi.org/10.1080/00031305.2016.1255257.

Lurie, W. (1958), "The Impertinent Questioner: The Scientist's Guide to the Statistician's Mind," *American Scientist*, 46, 57–61.

Olubusoye, O. E., Akintande, O. J., and Vance, E. A. (2021), "Transforming Evidence to Action: The Case of Election Participation in Nigeria," *CHANCE*, 34, 13–23. https://doi.org/10.1080/09332480.2021.1979807.

Ridd, M., Shaw, A., Lewis, G., and Salisbury, C. (2009), "The patient–doctor relationship: a synthesis of the qualitative literature on patients' perspectives," *Br J Gen Pract*, 59, e116–e133. https://doi.org/10.3399/bjgp09X420248.

Rossman, A. (2010), "Ask Good Questions," *ICOTS8,* Ljubljana, Slovenia.

Rossman, A. (2021), "Ask Good Questions," *Ask Good Questions*, Available at https://askgoodquestions.blog/.

Sharp, J. L., Griffith, E. H., and Higgs, M. D. (2021), "Setting the Stage: Statistical Collaboration Videos for Training the Next Generation of Applied Statisticians," *Journal of Statistics and Data Science Education*, 29, 165–170. https://doi.org/10.1080/26939169.2021.1934202.

Sharp, J. L., Wrenn, J., and Gerard, P. D. (2016), "Identifying the Perceived Value of Statistical Consulting in a University Setting," *Journal of Statistical Theory and Practice*, 10, 216–225. https://doi.org/10.1080/15598608.2015.1108254.

Vance, E. A. (2015), "Recent Developments and Their Implications for the Future of Academic Statistical Consulting Centers," *The American Statistician*, 69, 127–137. https://doi.org/10.1080/00031305.2015.1033990.

Vance, E. A. (2019), "Content of Collaborations QQQ," *Collaboration in a Bag*, 1–4. https://doi.org/10.17605/OSF.IO/XMTCE.

Vance, E. A. (2020), "Goals for Statistics and Data Science Collaborations," in *JSM Proceedings*, Alexandria, VA: American Statistical Association: Statistical Consulting Section, pp. 2198–2209.

Vance, E. A., Alzen, J. L., and Seref, M. M. H. (2020), "Assessing Statistical Consultations and Collaborations," in *JSM Proceedings*, Alexandria, VA: American Statistical Association: Statistical Consulting Section, pp. 161–169.

Vance, E. A., Alzen, J. L., and Smith, H. S. (in press), "Creating Shared Understanding in Statistics and Data Science Collaborations," *Journal of Statistics and Data Science Education*.

Vance, E. A., and Love, K. (2021), "Building Statistics and Data Science Capacity for Development," *CHANCE*, 34, 38–46. https://doi.org/10.1080/09332480.2021.1979810.

Vance, E. A., and Smith, H. S. (2019), "The ASCCR Frame for Learning Essential Collaboration Skills," *Journal of Statistics Education*, 27, 265–274. https://doi.org/10.1080/10691898.2019.1687370.

Zuckerman, M., Knee, C. R., Hodgins, H. S., and Miyake, K. (1995), "Hypothesis confirmation: The joint effect of positive test strategy and acquiescence response set," *Journal of Personality and Social Psychology*, 68, 52–60. http://dx.doi.org.colorado.idm.oclc.org/10.1037/0022-3514.68.1.52.