# How well can scholars explain their research to a lay audience?

*A study of explanatory writing skills among scholars in three countries*

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## Abstract

Seventy four (74) graduate students and faculty from the United States, Sweden, and South Africa wrote brief explanations of their research. These study participants were asked to explain their work so that a 17-year-old would understand it. Results provided an initial baseline description of explanatory writing abilities possessed by scholars around the world. Further, findings showed that 4 out of 5 participants were able to produce an account of their work that was adapted to the knowledge and interests of a 17-year-old; however, there was considerable range in the quality of those passages. Additionally, a 1-hour instructional intervention significantly improved the participants' explanatory writing. This latter finding suggests that instruction in explanatory discourse is important and should be made available to students and professionals world wide.

## Background

Specialization allows scholars in all disciplines to ask precise questions and create new understandings of complexities. Yet, specialization also tends to create a compartmentalized intellectual landscape that hampers cross-fertilization (e.g., Cummings, 1989; Metzger & Zare, 1999). An Italian scholar may have important mathematical ideas of considerable interest to a U. S. scholar studying the physics of human hearing. However, unless these two individuals happen to meet at a conference or during a social occasion, they may, because of disciplinary, cultural, and linguistic barriers, never realize that they have much to share with one another. Numerous scholarly associations have noted these communication challenges (e.g., Currie & Newson, 1998; Social Science Research Council, 2000) and argued that more should be done to help scholars collaborate across interdisciplinary boundaries.

Still another communication challenge created by academic specialization is that scholars often do not have opportunities to receive constructive feedback on their efforts at explaining their research

to interested lay audiences. This is an important problem because scholarly work must be shared to be useful and appreciated. Effective communication of research cannot occur unless scholars themselves determine how to give non-specialists access to such work. Unfortunately, there are even more challenges in sharing scholarship with lay audiences than there are with sharing scholarly work with colleagues outside of a disciplinary specialty.

For example, one especially revealing study helped to illuminate common problems that arise when scientists and engineers share science-based proposals with non-scientists. Weber and Word (2001) studied interaction in focus groups where scientists attempted to explain these proposals to non-scientists. The authors found that the scientists they studied tacitly subscribed to a "transmission view" of communication, where they saw themselves as sending an accurate, informative message to a passive audience who would accept and understand the message as it was intended. Instead, the nonscientists viewed what was intended as informative as a persuasive message. They distrusted the information they were given, understood scientific terms in ways other than they were intended, and interpreted scientific information in terms of their own past experience rather than in the frameworks the scientists intended. Along with Weber and Word's (2001) work, there are numerous other studies documenting the challenges associated with explaining scholarly work effectively to wide audiences (e.g., Friedman, Dunwoody, & Rogers, 1999).

Many agree that effective explaining-as-teaching is a complex human skill, and as in the mastery of all complex skills, people need opportunities for coaching, feedback, and practice to become proficient at it. Unfortunately, few professors and graduate students are given extensive support for explaining their latest research to lay audiences.

One important exception is a distinctive program offered by a U. S. West Coast research university. This university offers free workshops to scholars who wish to practice explaining their research to a non-specialist audience. This program has operated at this university for several years, and has been made available at several countries around the world.

Because of this distinctive program, it became possible to study the explanatory communication skills of several dozen scholars in the United States, Sweden, and South Africa. Consequently, this paper describes some preliminary findings about how effectively some of the world's top scholars explain their work through writing to a lay audience. The paper also reports findings on whether the instruction they received improved their explanatory communication skills.

### *Defining Explanatory Communication*

Explanatory communication is text designed to deepen understanding of subject matter unfamiliar to a lay audience (Rowan, 1985, 2003; Whaley, 2002). It's important to note that in this study, explaining is <u>not</u> defined as the sort of account experts generate for fellow experts. Instead, explaining is defined as a <u>teaching activity</u> where experts anticipate and attempt to overcome likely confusions that lay audiences might experience in attempting to comprehend unfamiliar ideas. The sort of explaining being studied occurs in classrooms, web sites, newspapers, popular science magazines, television documentaries, "infomercials," cooking shows, and many other mass media settings as well as in interdisciplinary face-to-face communication.

### *The Communication Workshops*

The workshops that created the opportunity to collect data on scholars' explanatory communication skills are multi-day enterprises. Often these workshops are popular with those for whom English is

not their first language; however, the focus of instruction is on ensuring that participants can explain their research to a lay audience, a skill that both native- and non-native English speakers need to master.

Because it is unusual to be able to study dozens of scholars explaining their research to lay audiences in a controlled, experimental setting, it was decided that the research question this investigation should pose is a simple one about the baseline capacities of these individuals. In these workshops, participants are asked to imagine that a 17-year-old with little background in their field has asked about their research. Consequently, this study posed a single research question:

> $RQ_1$: When scholars are asked to explain their research in writing to a 17-year-old, how adaptive are their texts?

Additionally, scholars as a group are unlikely to devote substantial amounts of time to practicing their explanatory communication skills. Consequently, the investigators wondered if a brief, one hour instructional intervention would be powerful enough to generate improvements. This question yielded the following hypothesis:

> $H_1$: Brief instruction in explanatory writing skill will increase the adaptiveness of scholars' explanatory writing passages.

In summary, the purpose of this study was to provide a description of scholars' abilities to produce adaptive written explanations of their work and to assess the effectiveness of a 1-hour instructional intervention aimed at enhancing scholars' explanatory writing skills.

## Method

### *Participants*

Participants in the study comprised 88 Ph.D. students, post-doctoral scholars, staff researchers, and faculty in the United States, South Africa and Sweden. At each university, many of the participants were not native speakers of English. In the United States, participants were students at a research university on the West Coast. Swedish participants came from two universities in the greater Stockholm area: a comprehensive university, and the largest technical university in that country. South African participants came from seven universities in the Cape Town region, along with researchers in government and industry. All participants had registered to attend free workshops on developing oral and written statements explaining their work to a lay audience. The study was conducted at the beginning of the workshops. Pre-test samples of participants' explanatory skills were collected first. Then, after 60 minutes of instruction post-test assessments were made. Pre- and post-test explanatory passages were available from 74 of the 88 participants.

### *Procedures*

All participants completed questionnaires asking whether they were willing to participate in this study. These questionnaires and all study procedures were approved by the institutional review board at the West Coast institution. Those choosing to participate were given 10 minutes to complete a pre-test answering the question: *Imagine that a 17-year-old student approaches you and says, "Tell me about your research." Write what you would say to this person.* Participants completed a 1-hour (60-minute) instructional intervention. The nature of this intervention is the

subject of another study based on his data set. In brief, participants either read articles discussing the importance of explanatory communication or completed group tasks that illustrated common obstacles to effective explanation.

All participants took a pre-test and post-test The post-test asked the same question that the pre-test had. That is, "*Imagine that a 17-year-old student approaches you and says, "Tell me about your research." Write what you would say to this person."*

***Dependent Measures***

All explanatory passages, both pre- and post-tests, were collected and then randomly ordered so that coders were blind to their status as pre- or post-tests. Two coders working independently assessed each passage for its explanatory writing adaptiveness, using a four-level adaptiveness coding system. On a set of 30 protocols, the two coders achieved 83 percent exact agreement (25 out of 30 passages were scored at the same level). To ensure accurate coding, each of the 148 passages was scored by each coder. Coding differences were resolved through discussion.

***Results***

Overall, the study participants generated relatively adaptive explanations of their work. As Table 1 shows, on both the pre- and post-tests, there was a greater number of participants earning scores at the higher end of the adaptiveness scale (i.e., scores of 3 or 4) than there were participants earning scores at the scale's lower end.

Table 1. Adaptiveness of Explanatory Writing Texts

| Pre-Test | Adaptiveness Level | | Number of Texts Scored at this Level |
|---|---|---|---|
| | Level 1 | 4 | |
| | Level 2 | 16 | |
| | Level 3 | 26 | |
| | Level 4 | 28 | |
| | Total | | 74 |
| Post-Test | Level 1 | 4 | |
| | Level 2 | 6 | |
| | Level 3 | 21 | |
| | Level 4 | 43 | |
| | Total | | 74 |

However, as Table 1 also shows, 20 out of 74, or 27 % of the respondents to the pre-test generated accounts that were scored at the lower two levels of the adaptiveness scale. After one hour of instruction, this number was halved: only 10 passages were scored at either a 1 or 2 for explanatory adaptiveness. Exactly what counted as an "adaptive" explanation is discussed further on.

In addition to asking a research question, the investigators also posed a hypothesis, postulating that brief instruction in adaptive explanatory discourse would be associated with an improvement in participants' explanatory writing efforts. To answer this question, the adaptiveness scores were examined using a paired samples t-test. Findings indicated a significant effect for instruction such

that the participants' mean score on the post-test ($M = 3.39$) was greater than the mean score for their pre-instruction explanatory writing efforts ($M = 3.04$); $t[73] = 2.48$, $p < .01$).

## Discussion

The existence of 74 pairs of short, explanatory passages generated by scholars around the world created a rare and important opportunity to develop a baseline account of scholars' explanatory writing skills. In this discussion, we first offer a look at the types of passages that were scored at each level of the coding scheme. Some speculations are offered about the "implicit communication theories" that generated either poorly adapted or well adapted explanatory writing.

### *Determining the Adaptiveness of Scholars' Explanatory Texts*

To assess the adaptiveness of the participants' responses to the pre- and post-tests, a coding system was developed. The coding system reflected the extent to a passage was judged by independent coders to be understandable by a 17-year-old. The system used was a four-level, hierarchical system where Level 1 was the lowest and Level 4 was the highest achievable score. This approach to coding adaptive messages is based upon Piagetian and Wernerian developmental theories that underlie a theory of communication known as constructivism (Burleson, 1984; Clark & Delia, 1979; Werner, 1957). Constructivist theory maintains that messages that reflect awareness of the need to integrate both the writer's and the readers' goals are more sophisticated and in principle more effective than those that reflect only the writer's goals.

At the low end of the adaptiveness scale, Level 1 protocols were those where the topic of the writers' text was clear, but little else in the passage was judged understandable to a 17-year-old with little background in the writer's field. For example, in Protocol 7, the author wrote:

> "I would start with the title of my research first. Then I would explain the words from that title in detail. For example, the title of my research is "experimental and numerical investigation of cross flow effects in two-phase displacements that occur in layered reservoirs." I am a petroleum engineer in deal [sic] with exploration, production and transportation of oil and natural gas. Oil and gas are found in underground porous rocks."

In this passage, the author offers a clear organizational framework to the reader (explaining each word in a long title). However, the actual explanation of each word is not given. Further, the author seems to assume that translating a complex title would be an effective way of helping a 17-year-old understand a petroleum engineering problem. Protocol 7 is typical of Level 1 protocols in that it focuses more on the topic of research and the researcher him or herself and far less on the hypothetical 17-year-old and experiences or knowledge this reader might have.

Another passage scored at Level 1 is Protocol 99. This passage reads:

> "I model the diffusion of drugs through the skin, using a method called finite elements. This is to understand better how transdermal drug delivery works and also to help improve their performance. The complex structure of the skin makes this quite challenging, and I'm looking a the diffusion on both molecular scales to molecular dynamics simulations and also at the macroscopic scale through finite element calculations. . . . . .

Again, this Level 1 passage begins with the word "I" and offers an account of the author's research activity. It does not begin by considering an aspect of the world that the reader may have experienced that has some relevance to the author's research. Instead, the implicit "communication strategy" generating Protocol 99 seems to be the notion that the author has been asked what he or she studies and the author has assumed the reader has nearly the same background knowledge of the project that the author does. In each case, the authors of these two Level 1 protocols seem not to realize that many 17-year-olds would have little understanding of "experimental and numerical investigation of cross flow effects in two-phase displacements that occur in layered reservoirs" or of a method called "finite elements." Because of this lack of adaptiveness, it's likely that a 17-year-old would be able to infer the topics that these two scholars are researching but little else.

Level 2 protocols were distinguished from Level 1 because both their topic and the gist of their core idea were judged likely to be understandable. However, in Level 2 protocols, less than half of the sentences elaborating that core idea were judged sufficiently clear for a 17-year-old with little background in the writer's field to comprehend. For example, Protocol 119 was scored at Level 2. It reads:

> "I study the effects of plant secondary compounds on herbivory.
>
> Plants produce primary and secondary compounds. The primary compounds like sugar are used in growth, but secondary carbon containing compounds have no known purpose in the plant's growth cycle. It is believed that these compounds may affect herbivore preferences as they are generally astringent to taste, i.e., they make the plant taste bitter. So plants may produce these compounds to protect themselves from herbivore damage or being eaten. . . . ."

In this case, the author's early use of undefined or unfamiliar notions "plant secondary compounds" and "herbivore" prevents the reader with no knowledge of these phenomena from following this explanation. The second sentence in this passage and the last sentence quoted above are probably the statements most likely to be understood in passage 119. The last sentence provides sufficient cues to help a reader realize that herbivores must be animals that eat plants.

Another Level 2 passage, Protocol 150, begins clearly, but quickly becomes difficult to comprehend:

> "Can you imagine how to construct a building in the future? My research is fundamental to the future construction—help construct a building fully automatically.
>
> To build a building, no matter how tall is, we need to erect structural elements piece by piece. Therefore my research change from finding the erection pass of each structural element by using path-finding algorithms in a tower crane. In other words, I develop an intelligent tower craned model which is able to erect structural element automatically . . . . ."

In Protocol 150, the author's ability to explain seems hampered by less-than-complete mastery of English. However, one can infer from the author's fourth sentence that this project involves programming a tower crane to "erect" (pick up? place?) building construction "elements." Because the topic and the gist of the author's core idea are understandable, this passage is best coded at Level 2 for adaptiveness. It cannot be given a higher score because in Level 3 passages "more than half" of the text is judged understandable to a 17-year-old lay reader.

At the higher levels of the coding scheme, the majority of a writer's text is adapted to a lay reader. In Level 3 passages, more than half of the text is judged fully understandable and in Level 4 passages, the gist of the entire message is clear. For example, Protocol 72 is a good example of a passage scored at Level 3 for adaptiveness. It reads:

> "I study plant genetics. My research group studies a particular group of plants that have the ability to remain dormant in times of drought. This plant can be rehydrated almost completely and then, when water is given, resurrect in 72 hrs. We look at what genes may be needed for this plant to have this ability. Ultimately we want to isolate the desired genes and put them into crop plants to make transgenic maize so they too have this 'resurrection' ability.
> In times of drought the crops will dry down, remain dormant and then recovery when the first rain comes. A farmer doesn't lose his crop."

As noted, this passage was scored as a Level 3. Its first and second sentences make it clear that this research involves plants that somehow resist drought. The passage's third through fifth sentences are effective at explaining that this research involves efforts to learn why some plants can be successfully "rehydrated" and how one might transfer this "rehydration" capacity to other plants. For this passage to have been scored at Level 4, however, the author would have needed to delete the unfamiliar term "transgenic" or find a way of explaining what transgenic crops are. Additionally, although the concept of resurrection is probably familiar to many 17-year-olds, offering multiple ways of explaining this point (e.g., noting that this research concerns plants that have the ability to revive after long periods without water) would have enhanced the passage's adaptiveness.

Indeed, the same study participant who produced this Level 3 text also produced a more adapted version scored at Level 4. Protocol 9 reads:

> "We have identified an plant that has the ability to "come alive" again after it has dried down completely. When most other plants would die after drying, or is plant "resurrects" once it is watered.
>
> We have identified various genes from this plant that allows it to resurrect so that we may use it to improve crop plants, e.g., maize. In South Africa, and currently in the western cape we experience water shortages which affects crops. If our crop plants could withstand water shortages then we could improve yield and management of our crops. . . . ."

Another example of Level 4 adaptiveness is Protocol 97. Protocol 97 is the post-test effort from the same author who previously earned a Level 1 for an account of drug diffusion through the skin (i.e., Protocol 99). Here is the more adapted Protocol 97:

> "I do a computer simulation of drug diffusion through the skin, that is, I look at how drugs pass through the skin and get inside the body. The skin has a very complex structure, which makes it difficult to model. So I first look at a tiny piece of skin, and simulate a drug molecule in that piece to figure out how it diffuses. Then I average the result from the piece and extrapolate to a larger area of the skin. This allows me to consider the complex skin structure within a reasonable amount of computer time.
>
> Understanding how the drug passes through the skin and into the body will help design better drug delivery products."

In this case, the author does not try to explain the "finite element method" discussed in the previously discussed Level 1 account of this topic. Instead, simple, familiar terms are used. The author writes: "I look at how drugs pass through the skin and get inside the body." In this more adapted version, the author also concludes with a sentence that helps the lay reader to understand why this research is useful: "Understanding how the drug passes through the skin and into the body will help design better drug delivery products."

Many of the most adaptive Level 4 passages were impressive for their emphasis on the readers' experiences. In fact, some of the most effective texts focused almost entirely on recalling an experience the reader was likely to have had and, only after having helped the reader consider this experience carefully, would the author note that his or her research focused on illuminating some aspect of that experience. Here is Protocol 138, which does an excellent job of discussing experiences the reader may have had and then using these familiar experiences to explain the author's research:

> "Computers are moving off the desktop and out into the world. Your cellular phone is one example of such technology. They can be very helpful but when your car breaks down on the road, but they can also be extremely distracting and dangerous if you talk on the phone while driving. My research looks at how we use, understand, and feel about these computers out in the environment as opposed to sitting on the desk. Using experimental methods from psychology, I study the human side of computer systems use. I'm mostly interested in voice interfaces such as the one you use when you call Moviefone. With the lessons we learned in the lab, we create design guidelines for computer interface designers to make future computer systems that meet the needs and capabilities of people rather than letting technology capabilities drive computer interface design alone."

Protocol 138 focuses the reader's attention on cellular phones and "Moviefone" interactions, both of which are likely to be familiar to a 17-year-old. While it is likely that 17-year-olds do not fully understand what this author means by "experimental methods from psychology" and "letting technology capabilities drive computer interface design," it is likely that 17 year-olds would understand the gist of this passage. It does a good job of helping them to consider their own experiences and the ways in which those experiences are examples of the author's research.

***Brief Instruction Improved Participants' Explanatory Writing***

In addition to understanding the range of adaptive explanatory skills, the participants in this study had, the investigators were also interested in whether a 60-miniute instructional intervention could improve participants' explanatory writing.

As the t-test showed, there was a significant difference between participants' mean pre- and post-test adaptiveness scores. This result means that the coaching these individuals received in just 60 minutes had a positive impact on the quality of their work. This finding is encouraging for a number of reasons. First, it is unlikely that scholars have a great deal of time for extended coaching in explanatory writing. If improvement can be seen after an extremely brief instructional intervention, that is an interesting finding. Second, the fact that some improvement was observed after this brief intervention suggests that substantially more improvement is possible from a more extended instructional intervention.

One indicator of how adaptive participants' accounts could be lies in a pair of passages explaining research on pilotless flight. In this case, the author of these passages scored a "4" for adaptiveness,

the highest possible score, on both the pre- and the post-test. Nevertheless, the post-test is still more effective than the pre-test. Here are both passages:

> Protocol 45 [pre-test]
>
> "Maybe you have seen on TV how they sometimes use pilotless airplanes in todays conflicts, for example Iraq, Afghanistan etc.
> For many reasons the military would like to us unmanned vehicles more often than today in future conflicts. Reasons might be that some operations are very dangerous and you don't want to have a pilot in the aircraft. Other reasons might be that you can increase the performance of the vehicle if you don't have to consider the limits that the human impose on the design. . . . . That's what my research is about."
>
> Protocol 82 [post-test]
>
> "Imagine what you could do with an airplane if you didn't have to have a pilot in it, but still could make it behave as if there were a thinking person inside.
> - The plane could be what ever size you want it to be, it doesn't have to have a person inside.
> - It could stay up for as long as there is fuel, no one needs to sleep, go to the bathroom, etc.
> - You could send the airplane on dangerous missions, noone in the plane will die if it crashes, it will only be a monetary loss.
> - The human constraints will not impose on the design of the plane. For example, g-loads.
>
> How this could be done is what I try to figure out."

Both of these passages explaining research on pilotless flight are impressive for their early focus on the reader's background knowledge and their reference to this likely background knowledge to explain the author's research. However, in this case, the post-test is particularly effective because the author is able to "partner" with the reader almost immediately, inviting the reader to imagine all the ways that pilotless flight might be a useful invention. Research on popular science writing shows that the best science writers often present intriguing puzzles to readers and invite the reader to enjoy the excitement and challenge of trying to solve the puzzle along with the researcher (Rowan, 1999). Protocol 82 seems to achieve this effect. While both it and Protocol 45 received the highest score possible in the current adaptiveness coding scheme, it may be that future coding schemes will need to describe higher levels of adaptiveness to reflect the skill that Protocol 82 reflects. At its most effective, adaptive explanatory writing should help readers understand the research being explained in a passage and allow them to puzzle thoughtfully with the author about that research. By taking readers to this level, excellent explanatory writing should generate vicarious reader involvement in research.

### *Limitations of this Research and Future Directions*

There are a number of limitations to this project. One challenge was that each study participant was explaining a different research project from a wide array of subjects such as psychology, education, pharmacology, computer science, petroleum engineering, aeronautical engineering, ecology, aquaculture, and so on. This fact made coding the adaptiveness of each passage difficult. Prior work on explanatory writing has held subject matter constant and asked all participants to explain the same idea (e.g., Rowan, 1990). In this study, it was not possible to have all

participants explain the same topic. A second limitation is that both the investigators and the study participants struggled over what to assume about the background knowledge of 17-year-olds. The investigators agreed that the 17-year-old hypothetical reader should not be expected to be familiar with the writer's research area. However, often it was difficult to determine what a 17-year-old should be expected to know as part of his or her background knowledge. In future work, the investigators plan to give the discourse collected for this study to actual 17-year-olds, or to first- or second-year college students and ask these individuals to rank order randomly selected sets of these texts for understandability. This step may provide information about the actual understandability of these texts as well as information about the validity of the current coding system and the formal features of explanatory discourse that affect understandability. Still other future steps include running readability measures for all explanatory passages and correlating them with coders' and readers' assessments of these passages.

Another future step is to explore the content of the 60-minute instructional intervention and the features of that intervention that were most responsible for improving the adaptiveness of the participants' writing. At the end of each workshop, participants were asked to complete an evaluation form, asking questions such as *"What is the one most helpful thing about writing that you have learned?"* and "*Are there any other valuable things you have learned during this workshop?"* Responses indicate that instruction enhanced participants' awareness of the importance of taking their readers' needs into account when explaining their work. For example, three participants wrote:

> "...we have become so used to using jargon in our writing and that by using these words we often exclude the general public from understanding our research and the possible impact thereof."
>
> "It is incredibly easy to forget how entrenched a person becomes within their field and this workshop has illuminated this point for me."
>
> "I would say it helped me to see the need for proper communication. Before I came here [workshop], I usually generalized my writing/presentations but now I realized not all the people are aware of your field. So there is a need to communicate your work in a layman's language."

As for the question, "What aspects of the workshop could be improved?" most participants stressed the need for more time to fully develop ideas. Comments included "Good writing needs time, especially writing for a general auditory. One has to rewrite the draft several times before it is OK," and "The course was very condensed -- it could be nice to have more time to go through all the interesting moments in the course."

Still another step may be to replicate this study. It may be possible to collect explanatory writing passages from scholars around the world using the Internet for data collection. It would be useful in future work to ask study participants to do several explanatory writing tasks, perhaps one task where all participants explain the same subject after learning about why a particular student finds the subject confusing. A writing task of this sort may be easier to score for adaptiveness. Following Weber and Word (2001), it would also be instructive to ask lay readers such as groups of journalism students to comment on their perceptions of the authors' intentions in explaining their research.

In summary, the present study found that scholars around the world are able to generate relatively adaptive explanations of their research. In addition, the study found that the adaptiveness of explanatory writing improves after brief instruction.

## Conclusion

The ability to explain a complex topic for a lay audience may be one of the most important communication skills specialists can command. Future work should be devoted to important questions such as learning more about why some people are better explainers than others, and which instructional interventions are most effective at improving the adaptiveness of writers' explanatory efforts.

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