Using the Scientific Method to Improve Mentoring

Saundra Yancy McGuire
Louisiana State University

Abstract

Many students who enter colleges and universities seem to be focused on memorizing and regurgitating information rather than on developing critical thinking and problem solving skills. Mentoring is crucial to help these students transition from the current approach to one that will be successful in college. Successful mentoring requires a structured approach. The scientific method can serve as the model for such an approach. An important component of successful mentoring involves teaching students about the learning process and teaching them effective learning strategies. Specific characteristics of mentors and protégés determine whether the mentoring is effective or not.

Mentoring is a well-established practice for helping individuals successfully negotiate new or unfamiliar territory. There are numerous mentoring programs operating in academic, corporate, and social settings. The role of the mentor is to help the protégé (student seeking assistance) develop habits and attitudes that will allow him or her to attain a much higher level of success than would have been the case without the mentoring. I have witnessed the significant impact of mentoring throughout the course of my 35-year career as a chemical educator and learning center administrator. In most cases, I have seen mentors make a significant and positive impact on student performance. However, in some cases the impact has been negative and has caused protégés to abandon their career goals. When the mentoring is done in a structured manner, based on specific principles and guidelines, the prognosis for a positive outcome is excellent. When the scientific method is used as a framework for structured mentoring, the results are very likely to be positive for both the protégé and the mentor.

The Scientific Method

The scientific method provides a standard protocol for asking questions and conducting experiments to find answers to the questions. A schematic of

For further information contact: Saundra Yancy McGuire | Center for Academic Success | Louisiana State University | Baton Rouge, LA 70803 | smcgui1@lsu.edu

the scientifc process, as shown below from the website www.sciencebuddies.org:

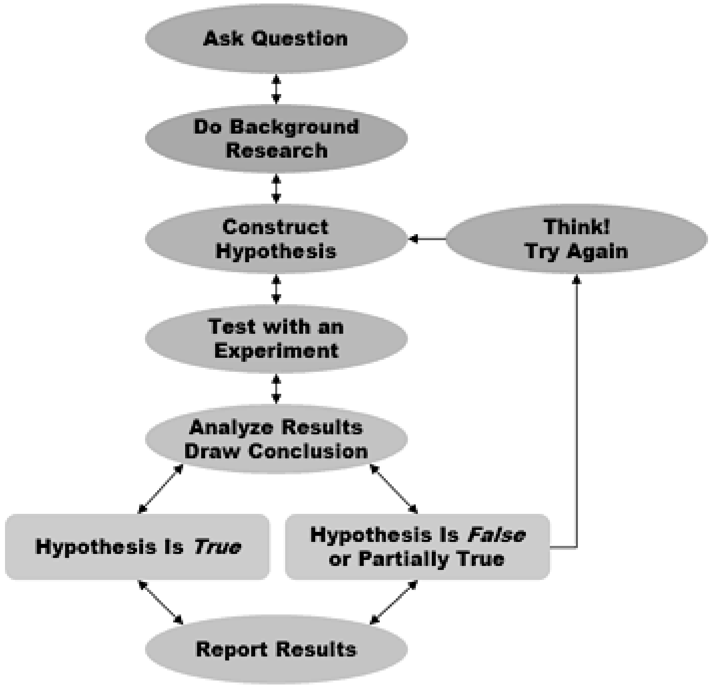

Figure 1. Steps of the scientific method

From "Steps of the Scientific Method," by M. Glass, 2007, from Sciencebuddies.org website, http:www.sciencebuddies.org/mentoring/project_scientific_method.shtml. Copyright 2007 by the Kenneth Lafferty Hess Family Charitable Foundation. Used with permission of the author.

Applying the Scientific Method to Mentoring

Asking the Question

The fundamental question that must be answered when entering a mentoring relationship is "How can I be the most effective mentor for this particular protégé?" The emphasis is on the particular protégé because all students are different. They come from different academic backgrounds, different cultures, different family situations, different past experiences with mentors, and many other different situations. Mentors can be effective only if they know as much about the protégé as possible without delving into areas that the protégé might consider too personal.

Do Background Research

Background research will yield information about the protégé's characteristics that will be very valuable in the mentoring sessions. Some of the characteristics that will be helpful to the mentor are listed below:

A. Preferred learning style: verbal, auditory, read/write, or kinesthetic

B. Personality style: Myers-Briggs personality profile characteristics

C. Cerebral Hemisphericity: Preference for right-brain or left-brain activities

D. Career Interests: research, teaching, health career, etc.

E. Cultural Background: minority or majority, urban or rural, socioeconomic status, etc.

In most cases, the protégé will not know his or her learning style, personality style, or cerebral hemisphericity preference, but this can easily be determined by having the protégé take a learning style diagnostic test that is available at a number of websites. The mentor should also take the diagnostic tests so that s/he will better understand how the mentor and protégé are alike or different in styles and preferences.

In addition to knowing the characteristics of the protégé, the mentor must determine the protégé's expectations of the mentoring experience. For example, a protégé who expects to be told what to do by a mentor will want a different kind of mentoring experience from the protégé who expects the mentor to help the protégé brainstorm several options that the protégé has constructed on his or her own. The mentor will need to gently move all students toward a position of self-sufficiency, but the initial encounter will be different based on the student's initial expectations. The mentoring philosophy at the Center for Academic Success is that protégés are adults who are capable of making sound decisions about their behaviors and activities when provided with strategies to develop choices. Mentors should guide students in developing a menu of choices and help them select the best alternative for a specific situation.

Construct Hypothesis

If the protégé is having difficulty in school, which is often the case when a protégé contacts a mentor, there are several possible causes, resulting in a number of hypotheses that can be considered. Although several factors might be responsible for the academic difficulty the protégé is experiencing, each one should be explored separately.

A. The protégé needs more effective learning and study strategies

B. The protégé needs strategies to deal with personal problems such as financial problems, relationship issues, etc.

C. The protégé needs a confidence boosting session to be assured that s/he can successfully negotiate the task at hand

D. The protégé needs organization and time management strategies

Based on varied experiences with proteges, by far the number one cause of academic difficulty is hypothesis A (above); the protégé needs more effective learning and study strategies. Therefore, this one is the focus of the experiment to be performed.

Test with an Experiment

In order to test whether a lack of learning and study strategies is really the problem, the experiment to be performed involves providing information on the learning process and on very specific strategies that can be used to improve learning. Information is also provided on how to access other campus resources such as tutorial centers, instructor's office hours, the Office of Career Services, and the campus Health Center. During subsequent visits, the protégé and mentor examine which actions produced posiive results. If the student's performance improves as a result of this information, the hypothesis is supported. If the student's performance does not improve, the mentor tests another hypothesis.

Learning and Study Strategies Information

Teaching Students the Difference between Studying and Learning

Because many students enter college without knowing how to learn or how to study, the Center for Academic Success conducts workshops with groups of entering first-year students to help them begin shifting their primary focus from grades to learning. When these students are asked to explain the difference between studying and learning, the most common response is that studying involves forcing themselves to memorize uninteresting information, whereas learning involves gaining insight into material of interest to them. They all agree that learning is fun, but studying is tedious. They further indicate that learning could and often does happen in the absence of studying, and studying does not necessarily result in learning. It was evident during the discussion that these students had not previously reflected on the difference between studying and learning, but that after the discussion they clearly understood the difference. One student who clearly understood the difference explained it as follows. He stated that studying involves focusing on the "what," whereas learning involves focusing on the "why," the "how," and the "what if." He found that if he focused only on the "what," he easily forgot the information. But if he focused on the "why," "how," and "what if," he could retain and apply the information. This understanding of the difference between studying and learning was the first step in helping students to turn unwelcome and tedious study sessions into engaging and interesting learning sessions. And they began to understand why a greater investment of time devoted to their academics was necessary.

Teaching students about metacognition and metacognitive strategies has proven to be very effective at helping students understand why their behavior should be changed if they want to succeed academically, especially in the sciences. Metacognition involves thinking about thinking. It involves the ability to be aware of one's self as a problem solver, to monitor and control one's mental processing, to recognize when one is simply memorizing facts and formulas and not understanding the application of the information, and to know that knowledge and understanding are not handed out by an instructor, but must be constructed by the learner.[1]

The examples of four students provide the evidence that when students are taught how to learn, their performance usually takes an immediate and dramatic turn for the better. The performance of four students that contrasts their performance before and after (underlined) being taught metacognitive strategies is shown below:

- Student A: junior psychology student
  Test scores: 47, 52, <u>82, 86</u>
- Student B: freshman chemistry student
  Test scores: 42, <u>100, 100, 100</u>
- Student C: junior organic chemistry student
  Test scores: 54, <u>82, 76, 78</u>
- Student D: freshman calculus student
  Test scores: 37.5, <u>83, 93</u>

When interviewed, each of these students indicated that understanding the difference between the way they had been studying before being taught metacognitive skills and the way they studied after they were taught metacognitive skills was the reason for their immediate and drastic improvement in their performance.

Teaching Students That Learning and Memorizing are Different

Cognitive psychologists make a distinction between rote learning and meaningful learning (Ausubel, Novak, and Hanesian, 1978). Rote learning is verbatim memorization and is not necessarily accompanied by any understanding of the terms. Students are unable to explain information that is learned by rote, and they are not able to paraphrase the information in their own words. Meaningful learning, on the other hand, is learning that is tied to previous knowledge, and it is understood well enough to be manipulated, paraphrased, and applied to novel situations. For example, rote learning about Charles' Gas Law involves the simple memorization that the volume of a gas is directly proportional to the temperature when the pressure is held constant. Meaningful learning, on the other hand, involves relating this law to the advice to motorists to reduce the pressure in their tires when embarking on a long trip on a hot summer day. Most learning is neither completely rote nor entirely meaningful, and it can be placed on a rote-meaningful learning continuum (Ausubel et al.).

Although most students enter college not knowing the difference between rote learning and meaningful learning, when they are taught this distinction, they are able to implement strategies that promote meaningful learning. When they fully understand the difference between memorizing facts and formulas for a test and working to understand the course concepts and how the concepts relate to each other, students' greater conceptual

[1] For a brief overview of metacognition, see the J.A. Livingston (1997) article, "Metacognition: An overview," for information on constructivist learning theory, see the M. Ryder (2007) website.

understanding and their success on problem solving tasks and examinations increases substantially.

One particularly effective way to present the different types of learning is through a discussion of the hierarchy of learning levels, shown below, similar to Bloom's taxonomy (Bloom, 1956). The difference between the representation below and Bloom's taxonomy is that the "knowledge" and "comprehension" levels have been subdivided into three levels: "recall," "translation," and "interpretation."

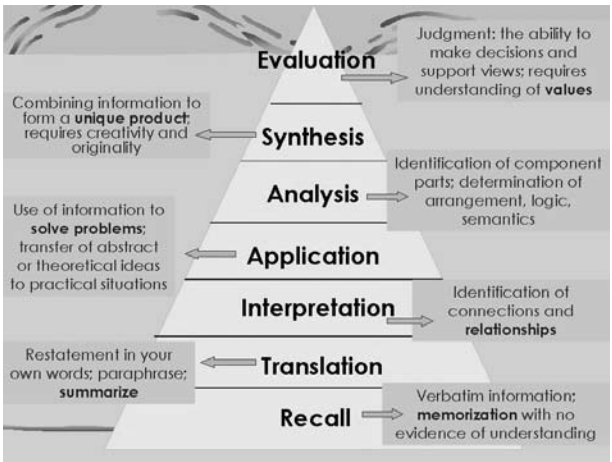

Figure 2. Hierarchy of learning levels

Although mentors generally assume that students know that memorizing information is not the same as learning, this assumption is unwarranted. Formally introducing them to differences in the levels of learning is crucial to developing the understanding of this distinction in today's students.

Teaching Specific Learning Strategies

The Center for Academic Success has had great success teaching students to use The Study Cycle with Intense Study Sessions. The four-step process is described below.

The Study Cycle

The four steps in the Study Cycle are adapted from methods that are commonly discussed in study skills textbooks and from a method proposed by Frank Christ (Personal Interview January 4, 2006).

Step 1: Preview or pre-read the information that will be covered in class before class.

Spending 10 – 15 minutes reviewing chapter material (concentrating on the bold-face print, italicized writing, figures, graphs, diagrams, etc.) prepares the mind to receive and comprehend the material that will be discussed in lecture. The previewing provides background knowledge for what will be covered in the lecture. Cognitive scientists have empirically demonstrated the importance of background knowledge to understanding and acquiring new information (Bransford, Brown, and Cocking, 2000).

Step 2: Go to class, and actively participate in lecture.

This step needs to be explicitly stated because absenteeism in large introductory science classes is often extremely high, approaching 50% after mid-semester.

Step 3: Review and process class notes as soon after class as possible.

Spending 10 – 15 minutes previewing and reworking lecture notes shortly after the lecture provides the mechanism for the information to be transferred from short-term to long-term memory, significantly improving retention.

Step 4: Use Intense Study Sessions.

Intense Study Sessions are concentrated study sessions of approximately 60 minutes duration. However, they can be as short as 20 minutes or as long as 75 minutes, depending on the individual student's need for a break. During this short, but focused, study time, a considerable amount of learning can be accomplished. The Intense Study Session consists of four segments, each of which is important for the session to have the maximum effect on learning.

a. 2 – 5 minutes:	Set goals for the next 40 minutes
b. 35 – 38 minutes:	Work to accomplish the goals that were set.
c. 10 minutes:	Review what was studied
d. 10 minutes:	Take a break

For example, a goal for an Intense Study Session in biology might be to master photosynthesis by learning the terms and the processes involved.

Most students find that the Intense Study Sessions are real "procrastination busters" – providing a means for targeted study sessions that are efficient and "doable." Short, focused sessions are more effective than three-to-four hour study marathons during which there is little meaningful learning accomplished.

Getting the Most Out of Homework

Many students who do well on the homework do poorly on the tests and question why they ace the homework assignments but fail the tests. The answer to this question lies in *how* these students do their homework assignments. The first question to ask a student in this situation is, "When you do your homework, do you read the problem, flip back through the pages to find an example similar to the problem, and then do the problem based on the example?" Invariably, these students read the homework problem *before* reviewing the information related to the problem, look for an example, and then "work" the homework problem using the example as the model. This one behavior is the reason that a large number of students think they have "done the homework problems," but that instead the examples in the book have done the homework problems. Students, however, usually see nothing wrong with this method of doing the homework problems, especially because this is the way they always did their homework in high school, and they did well in their courses there. A simple strategy that has proven quite effective in extinguishing this habit is found in the following bit of advice that mentors can give to protégés:

- When starting homework, study the information relevant to the problems as if they will be part of a quiz. Treat the examples in the text and in the notes as homework problems.
- Read the problem statement in the example, but do not look at the answer. Work the example problem by using information learned from studying the concepts.
- When an answer is first determined, compare that answer to the answer that is provided in the example. If the answers are the same, it is a good chance the problem was done correctly.
- Next look at how the problem was solved in the example to see if the attempted method of solving the problem was identical to the method used in the example. If it is not, and it easier to work the problem using the attempted way, continue to use that method to solve problems of that type. If the method used in the example is preferred, begin to use that method in the future. However, if the attempted method produces a different answer than the answer that appears in the example, study the concept to find the source of the error(s), and correct them.
- Continue to work on the example until the problems can be completed without making errors.
- After having worked the examples this way, solve the homework problems without looking at any examples. In fact, it is quite useful to pretend that these problems are for a test or a quiz.
- When finished with all of the problems that will be completed at that time, check all of the answers.

This advice is particularly helpful to students who may not be aware that the answers for many assigned homework problems are provided in an Appendix in the back of the textbook. Any problems that were not solved correctly should be noted and returned to at a later date, after reviewing the relevant material. Mentors are urged to tell students to "be sure to reread the text and your class notes on this topic; do not look only at example problems." Some problems may require several attempts before they can be done correctly without consulting any examples.

The process described should be repeated until all problems have been solved correctly without looking back at any examples in the text or in the class notes. When and only when all problems can be solved in this way can students be confident that they can solve any problem that is given. With an appropriate explanation students easily understand the difference in the skill being tested on an exam and the skill they are developing by using the examples to solve the homework problems. The skill being tested is not solving a problem by using an example, but rather solving the problem using only the protégé's effort. However, when they do problems only by consulting examples, the skill they are perfecting is the skill of solving a problem by using an example as a guide. The knowledge of the difference results in students changing the way they approach their homework assignments, and they see fairly immediate increases in their understanding of concepts, problem solving skills, and test performance. Whereas it would never occur to most students on their own that looking at an example to do their homework is counterproductive to performing well in the course, they are quite receptive to trying this new way of doing the homework because they understand why it works.

After all of the strategies have been provided to the protégé, the mentor can proceed to the next step in the scientific method.

Analyze Results, Draw Conclusion

If the result of providing protégés with learning and study strategies information yields an improvement in academic performance, the mentor can conclude that the hypothesis was true. If the performance does not improve, the mentor can conclude that the hypothesis may be false. Although it is possible that even with the information, the protégé did not change his or her behavior. In this case, the hypothesis would be true even though the performance did not change. Motivational strategies would then need to be used. If the hypothesis is not true, the next step in the scientific method must be implemented.

Think! Try Again

If the hypothesis proved to be false, the mentor can then propose an alternate hypothesis. For example, time management and organizational skills may be the problem. The protégé can then be directed to use time management tools such as weekly calendars, semester calendars, "to do" lists, etc. Whether the hypothesis was true or false, the mentor must report the results so that other mentors will have effective strategies to use with their own protégés. Mentors should not shy away from future use of strategies that proved ineffective with one protégé. The strategy that was ineffective with protégés with one set of personal characteristics may be very effective with a group of protégés with different characteristics.

Report Results

The results should be reported to a wide variety of audiences in a number of different forums. For example, results can be reported to the other faculty members in the department, to other faculty at the institution, at national conferences, and in newsletters and journals. When mentors have specific strategies to use with protégés, the likelihood of a successful mentoring experience is greatly enhanced.

Behaviors of Successful Mentors and Proteges

Mentors should always be cognizant that the protégé has different characteristics, skills, interests, and goals than the mentor. Mentors should be prepared to listen more than talk and be willing to brainstorm ideas with the protégé. Additionally, mentors should always communicate high expectations while always being prepared to help protégés deal with setbacks. And most importantly, the mentor should know when and whom to call if the situation requires outside intervention. For example, if a protégé exhibits signs of physical or psychological illness, the mentor should direct the student to a health professional on campus. Protégés should recognize that the mentor has experience and knowledge that will be beneficial and should approach each mentoring session with an eager and open mind. Protégés should also be willing to challenge the mentor on advice with which the protégé respectfully disagrees.

Several mentor and protégé behaviors have been linked with successful mentoring. Murray and Owen (1991) identify the behaviors linked with success mentoring as follows:

Behaviors of Successful Mentors

A. Act as a source of information on the culture, norms, and expected behaviors

B. Tutor specific skills, provide effective strategies

C. Give feedback and provide coaching

D. Serve as a confidante in personal crises and problems, where appropriate

E. Demonstrate confidence in protégé’s ability

F. Assist protégé in plotting a career path

G. Let protégés make their own decisions

H. Maintain the integrity of the relationship between the protégé and the protégé’s natural supervisor

There are also a number of behaviors that are associated with unsuccessful mentors, which are delineated below.

Behaviors of Unsuccessful Mentors

A. Controlling and manipulative

B. Self-centered

C. Legend in their own mind

D. Lack respect for protégé's intelligence and ability

E. Use personal information to undermine protégé

F. Take credit for protégé's work

G. Unwilling to remain on a professional level with protégé

While certain behaviors can be attributed to successful and unsuccessful mentors, there are also protégé behaviors that impact the success of the mentoring experience. These are listed below.

Behaviors of Successful Protégés

A. Interested in receiving advice

B. Receptive to constructive criticism

C. Spend time preparing for mentoring session

D. Unafraid of asking probing questions

Behaviors of Unsuccessful Protégés

A. Regularly miss appointments

B. Fail to heed advice

C. Refuse to take responsibility for their actions

D. Generally have an unenthusiastic and negative attitude

E. Rarely, if ever, express appreciation

F. Fail to give credit to the mentor for his/her assistance

Broader Implications

The application of the scientific method to mentoring activities is applicable to all academic areas – not just the sciences. Although my mentoring activities primarily involve students in the areas of science, technology, engineering, and mathematics, other faculy members at the Center for Academic Success mentor protégés in a wide variety of disciplines. The steps involved in applying the scientific method to mentoring are generally applicable to any mentoring experience. Learning about the characteristics of the protégé, developing hypotheses about the problem to be addressed, jointly developing a menu of strategies, implementing the strategies, analyzing the success, developing conclusions about the efficacy of specific strategies, and subsequently modifying strategies based on the results will make the mentoring experience an enjoyable and satisfying one for both the protégé and the mentor. The broad applicability of these methods suggests that they can be used for students in all types of institutions and at all levels. The specifics of the mentoring experience will change, but the basic framework is sufficiently robust so that, when applied according to the scientific method, it will yield positive results in any mentoring situation.

A number of additional references are quite useful for gaining additional information about cognitive science applications for improving learning. These references provide an excellent overview of the area as well as strategies that can be immediately implemented with students at all levels (Fisher, K.M., Wandersee, J.H., & Moody, D.E. 2000; Halpern, D.F & Hakel, M.D. 2002; Nilson, L. 2004; Peddy, S. 2001; Taylor, S. 1999; & Zull, James 2004).

Conclusion

The steps in the scientific method provide an excellent framework for successful mentoring activities. Increasing the numbers of students who are interested in pursuing careers in the sciences, technology, engineering, and mathematics will require improved mentoring to keep more students in the pipeline. The principles and strategies outlined above should prove useful for everyone who wants to significantly improve the impact of their mentoring activities on students.

References

Ausubel, D.P., Novak, J., & Hanesian, H. (1978). *Psychology: A cognitive view*. New York, NY: Holt, Rinehart, and Winston.

Bloom, B.S. (Ed.). (1956). *Taxonomy of educational objectives. The classification of educational goals*. Handbook I: Cognitive domain. NY: David McKay.

Bruer, John T. , 2000. *Schools for thought: A science of learning in the classroom*. Cambridge, MA: MIT Press.

Bransford, J.D., Brown, A.L., & Cocking, R.R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Fisher, K.M., Wandersee, J.H., & Moody, D.E. (2000). *Mapping biology knowledge*. Norwell, MA: Kluwer Academic Publishers.

Halpern, D.F and Hakel, M.D. (Eds.), 2002. *Applying the science of searning to university teaching and beyond*. New York, NY: John Wiley and Sons, Inc.

Livingston, J.A. (1997) *Metacognition: An overview*. Retrieved May 10, 2007 from CEP 564: Cognitive Psychology, State University of New York at Buffalo Springs Website: http://www.gse.buffalo.edu/fas/

shuell/cep564/Metacog.htm

Nilson, L. (2004). *Teaching at its best: A research-based resource for college instructors*. Bolton, MA: Anker Publishing Company.

Murray, M., & Owen, M. (1991). *Beyond the myths of mentoring*. San Francisco: Josey-Bass.

Peddy, S. (2001). *The art of mentoring: Lead, follow, and get out of the way*. Houston, TX: Bullion Books.

Glass, M. (2007). Overview of the scientific method. *Science Buddies 9* (internet image). Retrieved May 10, 2007, from http://www.sciencebuddies.org/mentoring/project_scientific_method.shtml

Ryder, M. (2007). *Constructivism*. Retrieved May 10, 2007 from School of Education, University of Colorado, Denver website:http://carbon.cudenver.edu/~mryder/itc_data/constructivism.html

Taylor, S. (1999). Better learning through better thinking: Developing students' metacognitive abilities. *Journal of College Reading and Learning*, 30(1),34-42.

Zull, James (2004). *The art of changing the brain*. Sterling, VA: Stylus Publishing.