THORNBURG
CENTER
Pragmatic Visionaries

Inquiry:

The Art of Helping Students Ask Good Questions

Executive Briefing
Number 402

by:

David D. Thornburg, Ph.D.
Director, Global Operations
Thornburg Center

847-277-7691
dthornburg@aol.com
http://www.tcpd.org

May, 2004

dthornburg@aol.com | www.tcpd.org
711 Beacon Dr. Lake Barrington, IL 60010 |847| 277 7691

> In some ways, we are all surrounded by a bubble of the known. When you "know" something, you identify how your model of the world fits with, and explains, what you see. Living in the bubble of the known is comfortable and comforting. You see what you know, and you know what you see. But to do inquiry, you have to get good at always looking for the boundaries of your knowledge, and at the limitations and contradictions within what is known. That is what scientists do. They are always looking for the limits, the boundaries, the points at which their theories fail to explain the world. Scientists, in essence, are always looking for that "door" from the known to the unknown, where they can press forth and push and, in a sense, expand the bubble of the known.
>
> Mark St. John (St. John, 2000)

The history of inquiry as an educational tool goes back at least as far as Socrates (Lamb, 1977). In the *Meno* we are treated to his instruction of a servant boy in a mathematical proof performed by the youth purely through Socrates' carefully posed questions. In the following two thousand years, our capacity to help learners through the process of inquiry has improved, even as the focus on education has shifted away from inquiry and sharply toward directed instruction. The battle between those who think academic excellence is measured purely by what you know, *vs*. those who think it should be measured by what you are motivated to find out, continues to rage with (in my view) insufficient attention paid to an approach that suggests that student inquiry can form a basis for the development of deep understanding of a content area that, by its nature, will result in students having a solid grasp of the "facts" of a subject, no matter how knowledge of these facts is tested.

Through inquiry, facts are learned, not by rote, but by the process of in-depth exploration with the following two benefits:

1. The material that is learned will be remembered for a long time, not forgotten at the end of a test.
2. The learner will not only have a solid grasp of a domain of inquiry, but may develop a passion for a subject that can last a lifetime.

Both of these goals are achievable, in part, in an educational setting that uses inquiry as a driving force for student projects in almost any subject at almost any grade, elementary through college. As noted on the *Inquiry Page* (Inquiry Page, 2004), "Inquiry education is where structure meets fluidity, where we can create opportunities for students to be engaged in active learning based on their own questions."

Today's challenge is that, with the aid of a textbook-based curriculum with microscopically proscribed content dictated by state agencies, many educators feel compelled to present students with the material they are expected to "know" in a well-intentioned effort to prepare them for a series of examinations geared to the content being taught. Even though scientifically based research shows the flaws in this approach compared with project-based learning (*cf.,* Reeves, 1998), teachers need active assistance in helping students learn how to ask, and find answers for, compelling questions.

This brief paper attempts to suggest an approach for addressing this challenge.

What makes a good question?

Questions can take many forms. Some reflect surface knowledge (Who was the 16th president of the United States?) Others call for observations (What is the temperature of the ore sample?) But questions that fall under the definition of *inquiry* are different in scope. Rather than asking for simple responses, inquiry addresses deeper issues. Taken literally, inquiry means not just questioning, but questioning *into* something. This type of questioning is rich because of the depth of exploration it encourages, and because each good question typically leads to more questions.

As an example, notice the difference between the following two questions:

1. How many stars are on the flag of the United States?
2. Why are states represented by stars on the United States flag?

The first question can be answered from memory or by simply counting the number of stars. Once answered, this question leads nowhere. The observation implies no deeper context.

The second question, though, not only forms the basis for a research project into the symbolism of the United States flag, it has the potential to open the door to further inquiries regarding the use of symbols in the flags of other countries. For example, a student exploring the topic of flags and stars might come across a picture of a Brazilian flag, which also has stars. What do those stars represent? Why did Brazil choose to use stars one way and the United States choose to use them another way? Questions lead to questions, and the process of inquiry leads to deep understanding of the role of symbols in the flags of nations. (Why, exactly, do nations and states have flags in the first place?)

It is the climate of the second kind of question that leads to student-directed learning. If learners can be encouraged to formulate powerful questions of their own, they will find their own focus for learning driven by forces far greater than the pressure to do well on the next examination. (In fact, I imagine some readers of this document will now find themselves exploring the topic of symbolism in flags just on the basis of the sample question posed above.)

While a complete definition of "good" questions is probably impossible, there are a few characteristics I think are useful in a rubric against which we can measure the quality of questions we or our students create related to their studies:

A good question is one for which:

- We do not already know the answer.
- The answers are defensible.
- The door is opened for in-depth research and projects.
- Anything from a class project to a doctoral thesis can be created.
- The focus is on causes (understanding), not surface knowledge.
- Other questions emerge.

Let's look at each of these characteristics in more depth.

We do not already know the answers.
This challenge confronts most educators at one time or another. Clearly there is a body of knowledge we want learners to grasp, and, as their teacher, we already have a grasp of this knowledge. So how do we ask students questions for which we don't already know the answer?

One approach is to formulate questions of sufficient depth to allow for new observations, or nuances of a topic to emerge. This encourages creativity on the part of the learner, and the possibility of bringing new knowledge into view. Even on topics for which answers are well known, creativity can be encouraged. For example, if students are learning about the Hundred Years War, you might ask, "How might the Middle Ages have developed had the English and French been close friends instead of frequent enemies?" The process of formulating scenarios based on this question requires that students first learn the underlying causes, costs, and consequences of reality as it happened, and then, armed with this understanding, speculate on how the world might be different if the circumstances were changed.

The answers are defensible.

It is important that learners are able to defend their answers, backing up their research with citations or direct evidence in support of their views. Certain questions can lead to defensible answers while others do not. For example, questions that ask for personal preferences are not defensible because the person who has formulated the answer has only his or her own personal reasons for the answer given. Questions that lead to research and/or verifiable experimentation lead, more naturally, to defensible answers. By citing primary source materials or experimental data, the student learns how to buttress her conclusions through the same mechanisms used by professionals in the field being studied. Citations become an important part of any research project because they reflect the scholarly nature of the work.

Now it may be that some of the cited work is inaccurate, and this leads to another reason that defensibility is so important. It is not enough to simply reference existing material, but to subject these references to close scrutiny in an attempt to insure that the cited work is accurate. Alan November provides a compelling exploration of this topic as it applies to a student conducting research on the holocaust (November, 1998).

The door is opened for in-depth research and projects.
A good question stimulates exhaustive exploration. While the depth of the study will depend on the age of the learner, even young students can find themselves captivated by a good question. In some ways, a good question takes hold of the learner and doesn't let go until an acceptable answer is found.

I recall one example explored by a young (10 year-old) student regarding properties of the factors of numbers. This student asked (and answered) a question on the distribution of certain types of numbers he was studying. His approach enlisted a computer in the search process by writing a simple program to factor integers and add the factors together, comparing the sum with the number itself. Through this brute force method, the student found some very interesting results which were later shared with a university professor who ended up assisting him with his work.

In this case, the student found himself captivated by the beauty of a branch of pure mathematics that continues to be a passion for him twenty years later.

Inquiry into any domain can lead to deep research projects – history, social studies, mathematics, science, literature – all are fair game. Furthermore, many professionals in these fields are delighted to guide and assist learners once they see the level of enthusiasm shown by students for the subject being explored.

Anything from a class project to a doctoral thesis can be created.
Most children ask compelling questions shortly after they learn to speak. Why, why, why, why? Why is the sky blue? If there is a speed of light, what is the speed of dark? Why does my shadow stay with me unless I jump? Why does the sun go away at night?

In the midst of these questions, there are some gems that can be explored at virtually any level of depth. Why do so many flowers have five petals? This question relates to research in the geometry of plants – a topic explored by Goethe, and numerous mathematical botanists since his time. While a young student may be content to build a table showing the number of petals in different flowers, a high-schooler might explore the relation of petals to Fibonacci numbers, and another student may explore the phenomenon of phyllotaxis. The underlying question remains the same; age merely determines the sophistication and depth of the student research.

The focus is on causes (understanding), not surface knowledge.
This characteristic is one way to clearly distinguish inquiry from other kinds of questions. For example, a student exploring the War of 1812 might know that the Battle of New Orleans was fought after the war was over. A question regarding the details of the battle, while interesting and worth exploring, is not the same as a question that asks how it was possible for a battle to take place nearly a month after the war was settled. This question looks into the causes behind an event, not just to the event itself. The beauty of these kinds of questions is that they lead to deep understanding of a subject.

As learners research a topic in pursuit of their lead question, causes are uncovered. The challenge is to continue the pursuit – to look for the causes behind the causes, and to keep going until a solid understanding of the subject of the question is in the learner's grasp. Questions designed to stimulate the recall of memorized information deprive the learner of the opportunity to dig deeper into a subject.

Some have argued that a challenge of the United States curriculum is that it is a mile wide and an inch deep. Students are expected to know a little bit about a lot of things, but are (so the critics claim) deprived of the chance to pursue any one topic in depth. In fact, carefully crafted inquiry provides the chance for in-depth explorations of a topic to lead to forays into side topics that build breadth of knowledge. This will not happen without guidance, however. Educators can encourage young people to explore how the patterns they uncover in their chosen topic might recur in other areas. For example, a student exploring the causes behind the censorship of Twain's *Huckelberry Finn* can be encouraged to also explore more recent examples of censorship in American history.

Other questions emerge.
As mentioned in the previous section, explorations can be expanded through the medium of additional questions. The important point here is that these new questions emerge naturally as part of the research process. Our ability to ask interesting questions is aided by our existing knowledge of the topic. As we learn more, new questions come to mind naturally.

I got to see this in my own education many years ago. During a graduate course in quantum mechanics, our professor was demonstrating the solution of a generalized wave equation in which he threw out all the solutions that related to particles with "imaginary rest mass." One student in class asked, if the original equations were accurate, why he could throw away half the solutions. The professor responded that these solutions were "non-physical" because they implied that these particles were traveling faster than the speed of light. Because we wanted to pass the course, we just accepted his response and moved on.

Meanwhile, in Boston, a biochemistry professor and science fiction writer (Isaac Asimov) encountered a need for particles that moved faster than light in one of his stories and asked why such particles could not, in fact, exist. Working with a professor from the physics department, the concept of Tachyons (particles that only travel faster than the speed of light) was not only born, but was published in a prestigious physics journal. Since that time, experiments designed to confirm the existence of these strange particles have been initiated all over the world.

While this example is somewhat abstract, it illustrates an important point. Once research has started, new questions will emerge, and these questions need to be respected, not dismissed out of hand without further thought. At the same time, learners need to be careful to not let the new questions pull them from their main quest. New questions should be written down for later exploration. They can (and should) even become part of the student's final project on the topic being explored. The ability to formulate new exciting questions is one indication that the original task was well-conceived.

How can you ask good questions if you don't know anything about the subject?
Questions can be used to explain or expand our pre-existing viewpoints. The less we know about a subject, the less likely our questions are to be well-formed. This is why many (but surely not all!) of the questions asked by very young children tend to be (to our jaundiced eye) whimsical. A child of two asking why the sky is blue is not looking for a dissertation on the refraction of solar rays from atmospheric dust. She is merely

asking for an explanation of a phenomenon she sees on a regular basis in terms she can understand. However, a high-school student asking the same question can delve into the topic with greater depth based on her grounding in physics. Content does matter – it forms the base on which new questions can be built.

The challenge for educators is not how to present content to students – most of us know how to do that very well – it is, instead, how to present content in a way that serves as a springboard for student inquiry. When viewed in this context, content can be provided in a more sketchy manner than would be expected in a traditional didactic presentation. An overview of the topic can be presented that highlights those events or phenomena that can lead to good questions. Once the hook is set, the process of finding answers to these questions will naturally lead to greater in-depth exploration of the subject, often to levels beyond those expected of the school's curriculum.

One of my favorite examples of this phenomenon was a result of a multi-year activity on Brazilian history designed by Norma Thornburg and her colleagues. Students were taught that in the 1600's Dutch settlers had created a major port city in the Northeast (Recife) and were later driven out by the Portuguese in a fierce war. One student decided to ask: "Who contributed the most to the culture of Recife, the Dutch or the Portuguese?" As a result of his study he learned far more about the history and culture of the area than would have been taught in a normal class. Furthermore, he had the opportunity to defend his conclusions in a debate with a history professor from the local university. The professor had written papers suggesting that the Portuguese provided the cultural elements of the region, contrary to the findings of the student. In pitched argument, the student defended his position and cited evidence that was so compelling it caused the university professor to acknowledge that he might be wrong! A photograph taken during the debate shows the deep commitment of the student to his point of view as he actively defended his position. This is the kind of learning that stays with students for life.

How do we assess the quality of questions?

Most educators are comfortable assessing student projects. The depth of student learning can be measured against pre-defined goals. It is trickier to assess the questions themselves, especially since the questions need to be assessed before they are answered. This is important because the quality of student learning will be determined by the questions each learner chooses to explore. Well-formed questions lead to deep explorations, and poorly formed questions do not.

I would suggest using the list of characteristics shown on page 3 of this report as a rubric against which to measure the quality of a question. It is not essential that every one of the criteria be addressed, but the more that are met, the better. For example, there are many excellent questions that can be formulated that may not make good doctoral thesis topics. There are other good questions for which we may already know at least part of the answer. (A sample rubric is included with this paper.)

The most important aspects are likely to be these:

- The answers are defensible.
- The door is opened for in-depth research and projects.
- The focus is on causes (understanding), not surface knowledge.
- Other questions emerge.

Inquiry is great; you go first.

Because inquiry is not the norm in many classrooms, students need to be taught how to formulate interesting questions. The easiest way to do this is for the first few projects to be based on questions formulated by the teacher. You can introduce a topic and then provide students with a list of questions from which they can choose to create their own research projects. You should be sure to invite them to add new questions of their own.

When looking for questions to ask, start with those that intrigue you relating to the topic being taught. What puzzles have you encountered in your own explorations of the subject?

Once you have students do a few projects based on your own questions, shift the responsibility of asking questions to them. Be sure they know how to distinguish between good questions and those that are not so good. Also, make sure students know that you will need to approve their questions before they start their research.

Once the research phase starts and students start to dig deeper into their topic, it is possible they will come across other interesting questions, one or two of which might be better than the ones they are answering. If a student wants to switch or modify a question based on a new discovery (something that scientists do all the time), you might want to let them switch, especially if the new question leads to deeper insights than the original one.

What are some examples of (potentially) interesting questions?

No matter what subject you teach, you are likely to think of many interesting questions in a very short time. The following list shows just a few questions from across the curriculum.

> We use base ten (decimal) numbers, but the Babylonians used base 60 for their arithmetic (just as we use 60 seconds in a minute, and sixty minutes in an hour). Why did the ancient Babylonians use 60 as the base of their numbering system? Why do we still divide time into 24 hours per day instead of using a number like 10 or 100?
>
> Every Fall, some trees in North America lose their leaves. What is the benefit to a tree in having its leaves fall off once a year? Why do some trees keep their leaves all year long?
>
> Many cultures use different hand gestures to signify phrases like "OK!" Why are hand gestures used? Why is it that a hand gesture that makes a positive statement in one culture can have a completely different meaning in another?
>
> Mark Twain was probably the first author to use a typewriter. Some authors today find it easier to create their work when they write by hand. Why is it, in today's world of word processors and spell-checkers, some writers still prefer generating hand-written manuscripts?
>
> Time travel is a popular theme in science fiction. Aside from the physical challenges of transporting oneself to another time, what challenges would arise if you were able to travel to a previous time and, while there, changed the outcome of an event before returning to the present?
>
> With the widespread access of telecommunications, daily newscasts report events in distant lands with the same clarity and depth as events happening in your own city. What impact does "global access" to the news have on our perceptions of the world? Given that a broadcast only has a limited time to convey the news, and wants to keep its audience fully engaged, what factors determine when an event is deemed "newsworthy," and what are the consequences of this decision for the viewing public?
>
> In the United States, we pledge allegiance to our flag while citizens of other countries pledge allegiance to the leader or their country itself. What is the impact of pledging allegiance to a symbol (the flag) instead of to (for example) a President or King?
>
> Some scholars have suggested that Shakespeare did not, in fact, write all of the plays attributed to him. Why would such allegations be leveled against such a great author? What evidence supports the critics? How could we tell if a work was written by its claimed author?

These are just a few of the thousands of questions you can create in a short period of time. Not all of these questions are equally powerful, but they all have the potential to lead to in-depth research, which is the goal.

Images as sources of questions

One very effective strategy for helping people learn how to formulate interesting questions is to have them take digital photographs of their surroundings, with the goal that each image is designed to stimulate an interesting question. When I do this activity with educators in a workshop setting, each team of teachers is sent out with a digital camera and given twenty minutes or so to take as many photographs as they want. When they return, their images are transferred to a computer where they can be edited and the best ones selected for a slide show. Each group then shares some of their images with the entire class to see what questions the images evoke.

There are many benefits that come from this activity. First, the questions asked by the class are likely to be different from the ones first thought of by the photographer. It is not uncommon for someone in the audience to see something in a picture that the photographer did not notice. Second, this activity provides more experience in the formulation of interesting questions.

When this activity is transferred to the classroom, students can be asked to take photographs germane to the curriculum. A life science class might concentrate on flowers, a math class on patterns in tiles on buildings, and so on. The possibilities are endless.

Other sources of questions: The Star Trek Phenomenon

Science fiction authors are inquiry-driven. Their fantastic adventures are often based on interesting questions, or suppositions of answers to such questions. How do we relate effectively with intelligent beings from other planets? If there are factors common to human cultures (*e.g.*, storytelling), do these factors exist among sentient beings from other planets? How might technologies of today get out of control in the future? At what point does virtual reality become "real," and how could we tell the difference between a simulation and the real thing?

I'm not a Trekkie, but I find that some of the episodes of the Star Trek television series (especially *Star Trek: Next Generation*) open the door to amazingly interesting questions. If television is not your favorite source for finding interesting questions, perhaps well-written fiction would be a better source for you. In this regard, I enjoy the writing of Neal Stephenson, Michael Crichton, Bruce Sterling, and many others. You should explore those who lead you to asking the kinds of questions that can help your students create strong curriculum-related projects.

The Knights of Knowledge

In an attempt to build bridges for educators interested in inquiry, Norma Thornburg and I have created a fictional ancient organization called the *Knights of Knowledge*. This group was founded in antiquity and included Socrates, Phythagoras, Archimedes, Newton, Galileo, Madame Curie, Pablo Picasso, Stravinsky, Georgia O'Keefe, Roger Bannister, and numerous others up to modern times. (For an amazing list of some of the Knights of Knowledge, browse the *Malaspina Great Books* site created by Russell McNeil at www.malaspina.com) Those selected for this secret organization had two characteristics: They asked, and answered, interesting questions. Second, each answer led to even more interesting questions.

Today, the Knights of Knowledge needs new members, and its leader (a mysterious woman whose identity is secret) has created a sub-group called the Special Agents. Students are invited to join the Special Agents and are given video-based assignments consisting of a compelling question which forms the basis of an in-depth research project related to the curriculum. Each video clip is only a minute or so in length – just long enough to set the stage for the challenge and for asking the question. From then on, the student is on her own to find answers and build a report, before generating follow-on questions of her own.

These video segments are in production at this time, and are based on national content standards in all academic subjects. We will be starting with middle- and high-school topics, and then moving to earlier grades. For information on the Knights of Knowledge, (and samples of the videos) contact the author of this paper.

What role can technology play in the inquiry process?

There are myriad ways that computers, the Internet, digital cameras, and other high-tech tools can be of assistance in the inquiry process.

For example, a web search on a topic conducted with *Grokker* (www.groxis.com) produces a visual map of the content domain of the search, broken into categories constructed by the software based on the contents of each web page. This tool provides a structure to a web search that is far more valuable than an unsorted list of the results such as that produced by *Google* (www.google.com). Because the *Grokker* map builds categories, the headings of these categories can stimulate the asking of new questions.

For example, a search on U.S. Civil Rights might reveal a category named Rosa Parks, which might lead a student to ask why her name was so important as to deserve its own listing.

As mentioned before, digital cameras are amazing tools for inquiry. Images allow you to stand back from an observation and reflect. The picture can be shared with others, and questions might emerge from shared images that would not come from the person who took the picture in the first place. For example, a photograph of a tree might show moss only growing on one side of the trunk, leading to an interesting question. Photographs of hundreds of flowers provides the opportunity to build graphs showing the frequency with which certain numbers of petals appear. Pictures of people engaged in conversation can lead to questions about body language. Artistic images can lead to questions about composition, artist intent, choice of color, etc.

One of the most powerful tools for inquiry-driven projects is "causal mapping," a technique developed by John Cradler that can be carried out with the assistance of a popular computer program, *Inspiration* (www.inspiration.com). Causal maps are built by starting with the event or topic under study. Once this is written down, the learner is asked to identify the causes of this event, and then to identify the causes behind the causes, and so on. Each layer of causes invites more research. Because the map contains text files with the results of this research, it can easily be converted into a document that forms the basis of a written report, or the outline of a multimedia presentation. (Interested readers can receive a causal mapping template by e-mailing the author.)

These are just a few of myriad ways technology can assist the inquiry process. Neal Stephenson once said, "All information looks like noise until you break the code." (Stephenson, 2000). Technology provides a tool to help students break this code as they pursue questions in support of their learning.

References

Inquiry Page (2004). University of Illinois at Urbana-Champaign (http://inquiry.uiuc.edu)

Lamb, W.R.M., translator (1977). *Plato II (Meno)*, Loeb Classical Library, Harvard University Press

McNeil, Russell (2003). *Malaspina Great Books*, (http://www.malaspina.com)

November, Alan (1998). *The Web: Teaching Zack to Think*, (http://www.anovember.com/articles/zack.html)

Reeves, Thomas C. (1998). *The Impact of Media and Technology in Schools*, Bertlesman

Foundation, (http://www.athensacademy.org/instruct/media_tech/reeves0.html)
St. John, Mark (2000). *The Value of Knowing What You Do Not Know*, Foundations, **2**, National Science Foundation, Washington, DC (http://www.nsf.gov/pubsys/ods/ub.cfm?nsf99148)
Stephenson, Neal (2000). *Snow Crash*, Bantam Doubleday Dell Publishers.

Technology resources:
Grokker (www.groxis.com)
Inspiration (www.inspiration.com)
QTI and QTI2 (www.ezedia.com)

About the author
Dr. Thornburg has been named one of the top ten presenters in the field of educational technology, and was named one of 21 "Pioneers of Educational Technology" by ISTE. Through his keynote presentations and stellar workshops, David reaches many thousands of educators per year, worldwide. He has also been a featured commentator on education for PBS and an advisor to the U. S. Federal Government on the humane uses of technology by children. He splits his time between homes in the United States and Brazil, and recently completed two global speaking tours in one year.

Through his numerous books and magazine articles, he has touched the lives of millions since entering the education field over twenty years ago. Prior to founding the Thornburg Center, Dr. Thornburg was a Principal Scientist at the famed Xerox Palo Alto Research Center, home to the invention of the personal computer, the ethernet, and the laser printer, among numerous other advances common to our world today.

Even though he has a shelf full of awards for his contributions in the field of education, Dr. Thornburg gains his greatest pleasure from the "Aha!" moments that often occur in his work with educators and children.

Inquiry Rubric (for evaluating questions before they are asked)

Question: ____

Attribute	4 points	3 points	2 points	1 point	Total
Answer is unknown	Neither teacher nor student knows an answer in advance	Teacher may have a general answer for the question	Teacher knows the answer in depth	Student knows the answer in depth	
Answer is defensible	Highly likely to find solid evidence for an answer	Some research or other good sources are likely to be found	Very little reliable information exists	Results likely to be virtually impossible to verify or defend	
Leads to deep research	Topic supports wide range of connections to the content area	Topic has broad expanse but not tremendous depth	Topic provides limited opportunities for research	Topic provides no opportunities for deep exploration	
Can apply at any grade	Topic worthy of research at all levels, K-graduate school	Topic limited to K-12 range	Topic germane only to student's grade level	Topic applicable at grade level below that of the student	
Focus on understanding	Leads to deep understanding of topic area	Leads to understanding germane to the specific question only	Leads to answer based on surface knowledge	Leads to answer based on rote information	
Leads to other questions	Topic triggers numerous other interesting questions	New questions are limited to refinements of the original question	Very few questions are suggested by the topic	No new questions are likely to emerge during the course of exploring the topic	

Contact the Thornburg Center at 847-277-7691 or dthornburg@aol.com