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**Scenarios by Sophomores:
Report on a Scenario Workshop with High School Students
On the Future Importance of Mathematics and Science in Their Lives**

by

Stephen M. Millett, Ph.D.; Constance Barsky, Ph.D.; Mrs. Tifani Kendrick, B.S.; and Mr. Leonard Sparks, M.A.

Background

In 1990 Prof. Peter Senge of MIT created a sensation in the business world with the publication of *The Fifth Discipline*, which went on to sell over a million copies and profoundly influenced corporations around the world. Among other points, Senge argued that successful companies and organizations must think in terms of whole systems and must not get locked into static mental models that inhibit creativity. He urged corporate managers in particular to continuously think, learn, and adapt to the ever changing circumstances of their businesses. (1)

Nearly 20 years prior to Senge's treatise on "the learning organization," scenarios were introduced to the corporate world as an innovative method for strategic planning. Scenarios are internally consistent but alternative sets of outcomes that describe plausible futures. They offer several different futures, told as stories, rather than a single-point forecast. Because they are largely qualitative, scenarios provide narratives with closely associated causes, effects, and likely consequences. In the early 1970s Pierre Wack and his team at Royal Dutch Shell in London worked closely with Ian Wilson at General Electric and then with Wilson, Peter Schwartz, and others at SRI International to develop scenarios as both a learning and a planning method. (2) The Shell approach of intuitive scenarios have become the most commonly used type of scenarios by all types of organizations. As Wilson wrote in 1998, using much of the same language as Senge, "Perhaps the most critical purpose of scenario planning is to challenge, test, and, if necessary, change decision-makers' assumptions about their present and future business environment. Through this process, scenario planning can remake executives' 'mental maps' of the world...."(3)

If scenarios can be used as a learning and planning tool for business managers, can it also be applied to teachers and students in educational organizations? Would we be so bold, in the Senge sense, to call schools, districts, and state departments of education "learning organizations"?

In 2006, one of us (Millett) organized and facilitated a scenarios exercise with the State Board of Education in Ohio. Among several foresights, the members of the board through the scenarios could clearly see the increasing importance of education to the future global competitiveness and economic

growth of Ohio.(4) In 2007, two of us (Barsky and Millett) participated in a scenarios exercise with the Ohio Mathematics and Science Coalition, a non-profit organization that champions STEM (science, technology, engineering, and mathematics) teaching in the public schools of Ohio. The emphasis of the analysis was placed on the dynamics of economic growth and the accessibility of all students throughout the state to high quality education in Ohio's public schools out to the year 2025. One of the major implications drawn from the OMSC scenarios was that communicating and motivating students directly is potentially just as important as reaching out to parents and teachers.(5)

The experience with OMSC led us to ask the following questions: do students, especially high school students, realize how important the learning of science and mathematics is for the quality of their future jobs and lives? Had anybody ever asked them? If students could more clearly see the importance of the STEM education for their future lives, see for themselves rather than being told by adults, then maybe they would more motivated to work harder and accomplish more results in their studies.

We formulated a hypothesis that high school students could generate scenarios as a method to think about, not just one, but several alternative futures involving different states of their education in science and mathematics in regard to any one of many possible dimensions of the future quality of their lives. If adults in many different companies and organizations could "learn from the future" through scenarios, then high school students, at one level or another, could, too.

Selection of Students for Scenarios

We selected as our student participants for a prototype scenario exercise a group of predominantly 15-year old sophomores (with a few 14-year old Ninth graders) from five different high schools in the Columbus school district who participate in the Miracle-Gro Capital Scholars program at COSI (the Center of Science and Industry) in Columbus, Ohio. We selected COSI because its orientation favored a positive attitude toward learning science, technology, and mathematics. The Miracle-Gro Capital Scholars program is sponsored by the O. M. Scott Company in Marysville, Ohio, and is designed to stimulate out-of-school cultivation of talents from diverse backgrounds. Our group was homogeneous in age, but diverse in gender, race, neighbors, grade point averages, and attitudes. We did not want to conduct the scenario exercise with selectively high caliber students from particularly excellent schools; we felt that the results were too predictable and would not be representative of large numbers of students in public schools in Ohio. Conversely, we did not begin with "tough" students in "tough" schools. We felt that they were not representative of all the students in Ohio public schools either. But the Miracle-Gro Capital Scholars at COSI gave us a sample that we believed would be more or less representative of most Ohio high school students.

The Scenario Method

For our scenario exercise with high school sophomores, we modified the intuitive scenario method to spread it out over three meetings of about two hours each. This readily fit the routine of the Miracle-Gro Capital Scholars at COSI. It also allowed breaks for the students to think further about the things said in the scenarios sessions. The three sessions were conducted on January 30 and February 6 and 13, 2008. The first session consisted of introductions, an explanation of scenarios, discussion of the topic question, and the generation of a list of the most important trends, issues, and factors relative to the topic question. The second session reviewed the list of trends, issues, and factors; selected the most important and the most uncertain for the future as the structure of the scenarios; and began the scenario narratives. The third session completed the scenario narratives and derived implications from

them for the lives of the students as adults in the future. In addition, we held a fourth meeting to discuss the process and the results with the students as a follow-up step on May 22, 2008.

We articulated four expectations for each student participant at the beginning of sessions:

1. Participate as instructed in the whole group to identify the most important trends, issues, and factors
2. Participate as instructed to generate scenario narratives
3. Make a list of insights and foresights (“lessons learned”) from the scenario exercise
4. Make a list of what you are likely to do about math and science education in the future

The Topic Question

The topic question for the scenario exercise as briefed to them in the first session and as repeated frequently was “What benefits do you think will come from learning and using math and science for the quality of your life as an adult in the future?”

The Most Important Trends, Issues, and Factors

The first session with the sophomores began with 20 participants. They seemed bewildered by our overview of the process and our expectations, but they were game. None was familiar with methods of thinking about the future or with scenarios. The facilitator explained that “futuring” is an approach to thinking about the future as trends and issues in the larger world, many of which are beyond our immediate control, while “visioning” is an approach to thinking about plans and actions to make desired outcomes possible.⁽⁶⁾ The former is analytical and the second is normative. We explained that we would begin our scenario sessions with futuring scenarios and then transition to visioning scenarios and implications for them. The students did not initially grasp the difference between futuring and visioning, but they were willing to suspend disbelief.

We began the process with idea generation using a modified Nominal Group Technique. Each student articulated a response to the question “What are the most important trends, issues, and factors affecting the benefits from learning and using math and science for the quality of your life as an adult in the future?” They generated 34 responses to the topic question. (For the complete list, see Appendix A). Then they were asked to vote for the ones that were the most important. The top four ranked by the most votes numbering three or more were

1. Develop thinking skills (10 votes)
2. Life applications – like doing taxes, paying bills, shopping, understanding interest rates, balancing checkbooks, etc. (7 votes)
3. Job learning opportunities (4 votes)
4. Sports: competitive and self-sports (3 votes)

The students were then asked to vote from the same list of 34 the ones that were the most uncertain. Several students were confused what “uncertain” meant in this context, so we had to explain the idea that some trends, issues, and factors were less certain than others in the future. We tried to relate “uncertain” to “most doubtful,” “least understood,” or even “most beyond your immediate control.” They still remained uncomfortable with the meaning of “uncertain” when applied to concepts involving what we would technically call judgment probabilities of future occurrences. When they voted, we learned that in most cases the students interpreted “uncertain” to mean the least valid of the trends,

issues, and factors for their lives in the future (meaning “uncertain” that they should appear on the list at all). The top five ranked by the most votes numbering three or more were:

1. Math and science are NOT important [meaning that they questioned the validity of this trend] (14 votes)
2. Music (7 votes)
3. Play chess and other games (7 votes)
4. Be able to facilitate groups (4 votes)
5. How to relate to other people (3 votes)

During this process, while one of us (Millett) facilitated the session and provided conceptual context for the sessions, another one of us (Sparks) had to co-facilitate, even translate the concepts into different words, in order to better relate to the interests and understandings of the students.

The Scenarios

The students were not required to attend the second session if they wanted to engage in another activity. Of the initial 20 students in the first session, nine returned to participate in the second session.

We reviewed what had been done in the first session, and the participants wanted to vote again on the most important and the most uncertain trends. The five that were voted as being both the most important and the most uncertain trends were

1. Stock market prices and the state of the economy and economic growth in general
2. Ecology: energy, natural resources, and global warming
3. Developing thinking skills
4. Health and hygiene to live longer and better
5. Getting through high school

Following the intuitive scenario method, the students agreed to take the economy and ecology as the two axes of a matrix with four quadrants. This structure provided four alternative futures:

- A. Great ecology and great economy
- B. Great economy and poor ecology
- C. Poor ecology and poor economy
- D. Poor economy and great ecology

We had originally planned to break the larger group into four sub-groups, one for each alternative future (scenario). Since we had nine student participants, we decided to generate each scenario with the whole group. After much discussion, during which the students offered ideas and challenged each other, four scenarios were generated, as seen in Figure 1.

The students recognized Scenario A as a highly optimistic one, when strong economic growth would create more and better paying jobs. It would also generate the resources to address various environmental problems, including global climate change. Scenario B, however, might produce strong economic growth, but with much more waste and pollution, which would not be managed as well as in Scenario A. In Scenario B, global climate change would emerge as a major problem. Also, people would likely suffer more health problems and generally have to pay more for goods and services due to additional expenses related to the suffering ecology.

The students characterized Scenario C as the “end of the world.” It reminded them of the recent Will Smith movie *I Am Legend*. There would be both declining economic growth and declining health.

		Great Ecology		
Poor		lack of money natural resources (good air, water quality) barter economy / some use of money be more civilized specialized workers “back to nature” less strict government (less taxation, less regulation, less services) people more dependent on each other strong families and tight-knit neighborhoods	no/Little welfare lots of well paying jobs no/Little homelessness lots of good water good air quality less global warming (stable climate, more predictable weather) better health/live longer; affordable healthcare Sustained rain forest/less acid rain & stable habitats for animals	Great Economy
		End of the world no money no way to live big decrease in population “I Am Legend” or “Blade Runner” setting more diseases must be <i>some</i> benefits or advantages somewhere war and chaos struggle for food and resources declining standards of living decline of middle working class get back to normal for survivors	decline in population more industry and business – may not be sustainable transportation problems garbage problems energy problems people stay at home polluted water and air serious global climate change (more violent storms) more expensive to live health problems	
		Poor Ecology		

Figure 1. The Four Scenarios Generated in the Second Scenario Session.

Quality of life would deteriorate. Yet, one student said that there must be some opportunity for something in this scenario.

They called Scenario 4 “back to nature.” The ecology would be great, but the economy would not. In this scenario, they thought that people would have to become more reliant on each other because there would be less money and that they would have to share scarce resources. They also thought that there would be a growing sense of neighborhood and community in this scenario. They saw the role of government as withdrawing from many social and economic problems due to the lack of tax revenues.

Three adults participated with the students in generating the scenarios. We asked questions to stimulate their thinking and we provided information along the way that they otherwise did not have. The adults, however, tried to restrain themselves not to lead the discussion or the thinking too much, recognizing that we were facilitating a process for the students to express their own thoughts.

Students’ Insights and Foresights

The same nine students who participated in the second scenario session also participated in the third and last session. We reviewed the scenarios as generated in the second session and they wanted to make several changes when asked specifically how these scenarios reflected the future importance of science and mathematics for their lives in the future. The second round of scenarios addressed more specifically the potential roles, both as they might be and as they should be, for mathematics and science in the context of the alternative futures for the ecology and the economy. Therefore the second round of scenarios was more normative, like visioning, than the previous scenarios, which were more analytical, like futuring. The revised scenarios appear as Figure 2.

In both Scenarios A and B, the students could see that mathematics and science can, and should contribute to strong economic growth (“great economy”). They were not clear exactly how, until some students pointed out that science and mathematics lead to innovation, new technologies, and improved health care. Science and mathematics would directly impact the quality of the ecology in both Scenarios A and B, with the problems of Scenario B creating many opportunities for scientific and technological solutions to environmental challenges, especially global warming.

The students made similar observations for Scenarios C and D. There would be problems of one kind or another in each of the four scenarios. One student observed with remarkable insight that each of the four scenarios presented problems for society in the future and that each presented challenges for math and science to address those problems, it was just that the alternative scenarios offered different sets of problems and different emphases on science and math. All the students could see how science and math could be used by them in coping with each of the four scenarios.

The students enjoyed a spirited discussion of the scenarios and their implications for answering the primary topic question. They began to verbalize their feelings that science and math may be more important, and relevant, to their lives in the future than they had previous thought.

Great Ecology

<p>Poor</p>	<p>(seems contradictory; this is hard to imagine)</p> <ul style="list-style-type: none"> • Little money (?) more bartering • Science improves the ecology • Math used to calculate value of currency and property • Science useful for inventing toys and games • Science useful for medicinal purposes 	<ul style="list-style-type: none"> • Use math to maintain high economy • May be a low demand for science and math • Use math to maintain wealth • Use math to track population – immigration may rise • Use science to cure diseases brought from high immigration • Use more natural resources in science health professions • Use technology to influence others to spread wealth and healthy ecology 	<p>Great</p>
	<ul style="list-style-type: none"> • Scientists and mathematicians are highly motivated to make improvements. • Use math to track the population • Use math to create currency • Use science to solve health problems 	<ul style="list-style-type: none"> • Math necessary for accounting for money & assets • Scientists more motivated to work in a low ecology • Science & technology necessary and useful for creating innovative technology • scientists and mathematicians are high in demand, make good \$ • Math useful for tracking population & growth 	
<p>Poor Ecology</p>			

Figure 2. Four Scenarios for the Potential Roles of Mathematics and Science in Each of the Scenarios Generated at the Third Session

At the end of the third session, the students generated the following list to the question of “lessons learned” by them through the three scenario sessions:

1. Math and science contribute to each scenario, although differently
2. Problems we will eventually face [referring to specific problems and trends]

3. No matter which scenario, we will have problems
4. You have to use math and science whether you like it or not
5. There are lots of benefits from math and science
6. Math and science help the world
7. What we do now affect things later
8. Hard to predict the future
9. The difference between futuring and visioning [the understanding of]
10. Utopia isn't what it appears to be

The final step was asking the students what action steps they thought that they might take in the future as a result of what they learned from the scenarios. Their list included the following:

- Be a scientist
- Be devoted to my schoolwork
- Stop polluting
- Pick up litter
- Become energy efficient
- Pay attention to world affairs
- Graduate from high school and college
- Be an advocate
- Vote
- Set a good example

Perhaps most importantly, the students expressed a new sense of relevance of science and mathematics to their lives and their environment than they had previously realized.

Students' Feedback on the Process and the Results

We held a follow-up meeting with four of the participating students on May 22, over two months after the last scenario session. We asked them several questions about the process and they offered several comments of their own. In general, they all enjoyed the process and found that, although strange at first, by the end of the sessions they had learned things that they had not known before. They more readily understood the difference between futuring and visioning and they had a clearer view on how they could influence their own lives and society in the future. The scenarios gave them a new sense of empowerment to learn and to use their learning in their lives. They strongly recommended that we do more of these scenario exercises with students in the following school years.

Our Observations on the Process and the Results

The four of us reflected on our experience and met together on May 22 to discuss what we had observed and learned from the scenario sessions. We also concluded that the scenario experience was sufficiently exciting to merit our writing a paper about it. Among our learning experiences, we have concluded that

- Sophomores can indeed generate scenarios with sufficient guidance, encouragement, and facilitation.
- At least nine of the students met and exceeded our learning expectations set at the first session.
- While we could expose the concepts and methods to many students, some would go along with us to the end and some would not. Maintaining their focus and attention over three sessions is

- We need to provide more background information and encourage the students to do more research on the trends, issues, and factors.
- The students enjoyed the experience and learned from it because it was highly participatory and interactive. They felt a strong sense of ownership for the scenarios that they generated.
- Students at this age need a strong sense that curriculum, instruction, and learning experiences are highly relevant to their lives. Relevance appears to be key to their positive motivation to participate in learning experiences.
- Students interact with more ease and comfort with adults whom they already know and trust than adults, no matter what their credentials, whom they have never seen or interacted with before – therefore teams of facilitators including adults familiar with the student participants as well as scenario specialists is highly desirable, if not indispensable for scenario exercises.
- Students can be motivated to see the importance of science and math in their academic careers, but they need to be motivated through their own learning experiences rather than passively being told it.
- Students can learn from scenarios, so scenario generation may be a method of learning for schools in the future.

Recommendations

Two of us (Kendrick and Sparks) will recommend that additional scenario sessions be planned for academic year 2008-2009 at COSI. We know that we had a very positive experience once, but we need to do more scenario sessions with more students to see whether our expectations can be generalized beyond this one case history. We might also wish to do a similar exercise with students' parents.

We may wish to explore the use of a diagnostic tool before the scenario sessions and one afterwards to better measure and quantify learning outcomes. While we achieved our four learning objectives, we felt afterwards that we could make many improvements to the process in the future. We recognize that our initial scenario experience with this age group was a kind of prototype exercise that we need to further develop for sustainability, dissemination, and consistent high quality.

We also will need to do more preparation for students in the future. We need to give them more advance explanations of what we are going to do and why. We also need to provide more background information and give them explicit homework assignments. One thing that we did not do in this prototype exercise was direct the student to doing research on the trends and issues that they identified. This step should be added in subsequent scenario exercises.

Two of us (Barsky and Millett) are planning to explore further how scenarios and simulations of all kinds might be introduced into the standards and model lesson plans for public schools in Ohio. We would like to try scenario exercises in individual schools to see how the scenario experiences might be similar or different to the experience with the Miracle-Gro Scholars at COSI.

References

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4. Stephen M. Millett, "Public Education in the New Global Economy, 2006-2016 (2007), posted at www.thinkglobalohio.org/tgo/pa/ar/ar_o6-16.html. A different version of this paper appears as Stephen M. Millett, "Public Education in the New Global Economy 2006-2016," *Futures Research Quarterly*, Winter 2007, Volume 23, Number 4, pp. 57-81. In 2000, Drs. Barsky and Millett had a previous successful experience with college students generating scenarios for the future of the university at Denison University. Dr. Barsky has been closely monitoring the use of scenarios for planning in educational institutions. She is particularly interested in the generation and use of educational scenarios by the OECD. Dr. Millett was involved in a previous scenarios exercise with the Ohio Department of Education in 2003 involving the cross-impact analysis, modeling, and simulations approach to scenario generation called Interactive Future Simulations (IFS), which was developed at Battelle and managed for nearly 20 years there by Dr. Millett. See Stephen M. Millett, "Case study: Scenario analysis and a logic model of public education in Ohio," *Strategy & Leadership*, Vol. 33 No. 2, 2005, pp. 33-40.
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The Authors

Stephen M. Millett, Ph.D., is an internationally respected futurist and expert in scenario generation. He is the founder and Managing Member of Futuring Associates LLC. He is also a Member at Large of the State Board of Education in Ohio.

Constance Barsky, Ph.D., previously managed with Nobel Laureate Kenneth Wilson a program for innovation in the education of science for the Department of Physics at The Ohio State University. She is currently responsible for developing innovative science education initiatives and policies at the Ohio Department of Education.

Mrs. Tifani Kendrick, B.S., is Director of the Miracle-Gro Capital Scholars program at COSI (Center of Science and Industry) in Columbus, Ohio.

Leonard Sparks, M.A. Master Educator of Student Programs at COSI in Columbus, Ohio.

Attachment A. List of the Most Important Trends, Issues, and Factors Generated by the Sophomores in the First Session with Votes

1. **Develop thinking skills(10=O)**
2. Understand the nature around you-clouds, dark, and rain(1=O)
3. How the solar system works
4. **Job learning opportunities(4=O,1=G)**
5. velocity[f=ma] (Newton's Physics, like driving a car)(2=O)
6. **Life applications- like taxes, paying bills, shopping, interest rate, balancing check book(7=O)**
7. stock market prices-401(k),(1=O)
8. Do your job better(1=O,2=G)
9. Resourceful-how to solve problems like global warming(1=O,1=G)
10. Solve everyday problems(2=O)
11. Getting into a good college (1=O)
12. Math helps to do science
13. Learn to operate machinery (cash register; quality control)
14. Do things you don't know how to do (science of temperatures and weather) (1=O)
15. Building things – like architecture and construction
16. Monetary value (1=O) (1=G)
17. Teach others especially younger- mentoring (1=O)
18. Health/Hygiene: if you're sick, you need to know some science. (2=O)
19. To get through high school (1=O)
20. To improve on things; fix breaks and problems at home (2=O)
21. Communication among scientists and mathematicians around the world to solve economic problems (1=G)
22. Science leads to a math problem: math and science go together
23. Explain things: why & how (1=O)
24. Having a family / child development (2=O; 1=G)
25. Pet Care (1=O; 2=G)
26. **Math and science are NOT important (1=O; 14=G)**
27. Plants: Identify plants, care for plants
28. Sports: competitive and self-sports (3=O)
29. **Play chess and other games (7=G)**
30. Ecology: renewable resources (2=O)
31. Who we are – heredity
32. How to relate to other people (3=G)
33. **Music (2=O; 9=G)**
34. Be able to facilitate groups (4=G)

O=Orange most important trend; G=most unknown trend