

Replicating a Successful Authentic Science Research Program:

An Interview with Dr. Robert Pavlica

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In this interview, Dr. Robert Pavlica discusses the Byram Hills High School Authentic Science Program, which he founded and directs. This program has been replicated in school districts throughout the country, and the expense to start and maintain it is minimal. Students are self-selected into the program based on their desire to study and succeed, not on their grade-point average. By undertaking this 3-year program, students learn not just about science, but how to do science like a practitioner in the field. First, students identify a topic they wish to investigate by doing an extensive review of articles. Then, they find a mentor to help them do research on their topic. Finally, students publish their results. In 2004, Byram Hills High School, which has only 600 students, was tied for first place in the nation with respect to the number of finalists and semifinalists in the Intel Science Talent Research Competition.

The Authentic Science Research Program at Byram Hills, founded by Dr. Robert Pavlica, has been replicated in more than 170 school districts in the state of New York, as well as in districts in five other states. Dr. Pavlica's success can be attributed to student choice, a unique mentor program, and a spiral curriculum. Results of the 2002 Intel Science Talent Research Competition, which were released after this interview took place, reported that Byram Hills High School, which has a student body of only 600, had eight semifinalists and one student who went on to become a finalist.

JSGE: In 2001, your students achieved great recognition. Would you tell us about them?

Dr. Pavlica: At Byram Hills High School we have approximately 600 students. It's the traditional public school. It's not a magnet school. There are 73 students in the Science Research Program. That's more than 10% of the school doing science research. And, if you think about it, that's more students doing science research than are on the varsity football or basketball team. These students are the future of our country. Well, this

year, I had nine seniors, and they all, as part of the course requirements in Authentic Science Research, entered the Intel Science Search. Of the nine seniors, seven of them were chosen to be semifinalists and three of the seven were chosen as finalists, which represents the highest amount of finalist of any school in America. This success that I am talking about is doable in other schools.

JSGE: You're saying that your Science Research Program is replicable?

Dr. Pavlica: It's quite replicable. One of my roles as the academic director of Authentic Science Research in the high school is to teach teachers across the country how to replicate this program within their classes. Presently, in New York State, there are more than 170 school districts using the program. In addition, the program is being replicated in Missouri, California, Florida, New Jersey, and Connecticut. There are textbooks that supplement the training for teachers and there are textbooks for the students. It's highly replicable. In fact, New York State's Sharing Success Programs adopted my program as the model for the state.

JSGE: Where did the idea for this program come from?

Dr. Pavlica: That's a good question and a very interesting one. Twelve years ago, I was teaching AP Biology, and a student in my class, Abe Shahim, came up to me and he said, "Dr. Pavlica, I have taken every AP course that Byram Hills has to offer. I'm taking AP Biology now. I've taken AP Chemistry. I've taken AP Physics at Purchase College. I've taken AP Calculus." He went on about his AP courses, and then he said, "I don't know a damn thing about science."

I looked at him and I said, "Abe, what do you mean?"

And he said, "All I've ever done in my life is be a good student—meaning I listened to what the teacher told me, then I memorized what the teacher told me, and then on the next exam I wrote down what the teacher told me. And I got an A. That is not what I want to do." He said, "I want to do science."

Right after that conversation, within a week, Abe was in the laboratory. He devised his own experiment working with bacteria. Abe then went on to Columbia and now is Dr. Shahim, a pediatric psychiatrist at Luke's hospital in New York City.

JSGE: How long have you been directing the Authentic Science Research Program?

Dr. Pavlica: The program has evolved. The program has been officially in my school now for 11 years. The students started to enter the Intel Science Talent Search in the third year of the program. So, for approximately 8 years we've been entering Intel because you must be a senior to enter. In the last 8 years, we've had 27 semifinalists in the Intel Science Talent Search, which used to be called the Westinghouse Science Talent Search, and 8 finalists. What is nice is, of the 27 semifinalists, 3 of them have come from special education. One of those three became a finalist. These are kids who had been written off in school with C's and D's, who were not interested in school. They came into the Science Research Program, where they could study what they wanted to study in the depth they wanted, and they had three years and two summers to do it. It's amazing! The reason why they were in special education is because somehow education was turning them off and we should be turning them on.

JSGE: Can you give me an example of turning students on and off in your school?

Dr. Pavlica: I want to tell you a story about a special-ed kid who was in the Science Research Program for 3 years. This student studied a topic in psychology. She had a mentor at a university, and she entered the Westinghouse Science Talent Search. In those days, the Westinghouse representative called up the students around Martin Luther King Day. They call

up this student and said she was a winner in the science competition. I get home and on my answering machine I hear a crying girl hysterical on the phone saying, "Dr. Pavlica, please call me back!"

I called her back. It had to be 10:30 at night when I got her on the phone and asked her what was the matter.

Sobbing she said, "Dr. Pavlica, I was chosen as a finalist in the Westinghouse Science Talent Search."

I said, "You mean a semifinalist, right?"

"No, Dr. Pavlica, I am a *finalist*."

It was incredible! The next day in school—balloons, *The New York Times*, congratulations from the principal and superintendent, etc.

About a week later, the girl came into my office crying. I asked what was the matter. She was crying a deep hurt cry. She said, "Dr. Pavlica, all my friends are telling me I'm not smart enough to win this Westinghouse. They're saying you did all the work for me and that I didn't do anything because I'm a dumb person."

I looked at her and she was hurt. So I said, "What have I done for you?"

She stopped crying. It was amazing. She turned white, backed away from me, raised her finger and said, "Dr. Pavlica, you haven't done a damn thing for me!"

"That's right. You did it all yourself."

That's when she realized she had done it all herself. Six months later, we had the awards assembly where the students are honored and plaques are given out. I got up on the stage remembering what pain her supposed girlfriends had put her through and spoke about how hard she had worked to get this award from Westinghouse. After she received her plaque, the entire school population, including parents, gave this girl, our first Westinghouse finalist, a standing ovation. She finally got what she deserved. She went to a college in Boston, graduated magna cum laude, and is today a Ph.D psychologist.

JSGE: How did special-ed students come to be in your program? Aren't there entrance requirements?

Dr. Pavlica: No, there are no entrance requirements in the traditional meaning. The only entrance requirement is simply that the student has the desire to do research, has the desire to study something that he or she could not do under ordinary circumstances.

JSGE: How does a student get selected to enter the program?

Dr. Pavlica: It's a very simple process. All you need is the desire to study and succeed. I gather the entire freshman class in the theater during first period because our schedule allows it. If it didn't, I would go to every ninth-grade science class and make a

presentation. At that presentation I have two seniors, a boy and a girl; two juniors, a boy and a girl; and two sophomores, a boy and a girl. Each one of these students is from a different segment of our school population. There may be someone there in theater, someone in math, someone in sports, and someone in a leather jacket. I simply tell these kids to go on stage and explain to these freshmen why this is the best program in the school, why they should sign up for it, and why all they need to succeed in this course is their own desire to study what they want to study and the desire to succeed; nothing else is needed. When the ninth graders see the different segments of society in front of them from our school, they basically say to themselves, "I'm just like him or her. Why, I can do it." And the kids sign up.

Now, it just so happens that this past year we had approximately 120 freshmen in the ninth grade. Fifty-three signed up for the program. So, how does the teacher screen those kids? The teacher doesn't screen them; the students screen themselves. Each student is given an essay or two to write on a topic such as "Explain to me your creativity" or "Explain to me your work ethic." These questions came off the Intel essay that the seniors are asked to answer. The students are asked to complete these essays and place them in my mailbox, double-spaced, bound in little plastic folders. I give them 2 weeks and 1 week-end to do it. The test is: Anyone who does it is in the program. Anyone who doesn't do it has disqualified himself or herself. From the 53 students who first signed up for the program, 33 filled out the essays and entered the program. So, that's the only requirement. The kids think it's about what they write and the style of their writing, but my thought is "Show me the work." If they can walk the walk and do what they are asked to do, then they are in.

JSGE: What is the central focus of your program?

Dr. Pavlica: It's called "the science research thread." All the activities the students do in senior year, junior year, and sophomore year focus exclusively on the identification of a topic, the review of literature, hypothesis, objective or purpose, methods and materials to be used, the results, the interpretation of the results—meaning the discussion—the conclusion of the work, the significance of the work, and acknowledgments to the work. That spiral curriculum is found in six, seven, or eight different disguises. Every senior, junior, and sophomore is doing each of those segments six, seven, eight times a year (see Figure 1).

JSGE: How much time do the students put into this course?

Dr. Pavlica: My students put in 9 hours every 2 weeks. It's documented in a lab book. They keep the lab book in a highly structured and organized portfolio that has 18 sections. It was

created by the students themselves as a place for every activity in the program. They keep the portfolio for 3 years.

JSGE: Intel winners are not the aim of your program, but a by-product. How would you describe your program?

Dr. Pavlica: The purpose of the program is to have students do authentic science research as a way of life. The skills they learn from Authentic Science Research are transferable. They learn how to manage time. They learn how to prioritize, put activities in categories, write scientific papers, write within word limits, do abstracts, make posters, communicate with professionals in the field, work cooperatively with professionals and other students in the course.

So, there are short-term benchmarks like the Intel competition, but the ultimate goal, in my opinion of why I started the program, was to create more Ph.D.'s in math and science in America, to create more MDs in America, and to create more engineers in America. If you go to a university and go to a Ph.D. graduation, you will notice that approximately 80% of the Ph.D.'s in math are foreign students who then go back to their country of origin. We have a brain drain occurring in our universities. In science, approximately 60% of the Ph.D.'s are foreign and many leave our country. Although the universities have a good population of Ph.D.'s, what's left in America 10 years later is not a good population of Ph.D.'s. So, ultimately the purpose is to create students who have transferable skills to become good mothers and fathers, to become writers and engineers, Ph.D.'s, artists, all with the skills learned from grappling with their subject matter.

JSGE: What has happened to the students in your program after they leave? Do they go on for advanced degrees?

Dr. Pavlica: Yes, this is very exciting and, as an educator, very rewarding. Approximately 58% of the students who have graduated from my program in science research are presently MDs or getting their MDs, are Ph.D.'s or getting their Ph.D.'s, are engineers or getting their engineering degrees.

JSGE: In addition to the help you give to your students, do they get help from any outside sources with their projects?

Dr. Pavlica: Yes, that's an excellent question. There's a triangulation that's involved here: the science research teacher who basically organizes the 3 years of sequencing of the students' work, the students themselves, and their scientific mentor. Every student in the program must have a scientific mentor either from a university, a laboratory, or industry. The students do their work in the universities, laboratories, or possibly in the field with an organization such as the Department

1. Sophomore Year

- a. The sophomores observe, study, and analyze the classroom presentations of the juniors and seniors. At this point they begin to see and understand the scientific method. They are required to make judgments about the presentations which they are observing by grading the review of literature, hypothesis, methods, results, discussion conclusions, and the research significance.
- b. The sophomores study the “funnel” and why the paragraphs were placed in specific sequences, viz. butterfly, red butterfly, red butterfly with white spots, red butterfly with white spots that pollinate.
- c. The sophomores write their Mid-term Paper found in Report 16.
- d. The sophomore Third Quarter Dissection of a scientific article. Here the sophomore analyses the paper of their mentor according to the rubric provided.
- e. The Sophomore Third Quarter PowerPoint presentation in class and at the symposium, before the symposium in Large Group, and at the symposium, the sophomore must present his/her poster following the Research Model.
- f. *The first large group meeting of each new quarter is reserved for the following activity, “The Creation of the New Quarter’s Research Plan”:*
 - i. The students write a statement of what they have accomplished over the past quarter.
 - ii. The students create goals they wish to accomplish in the next quarter.
 - iii. The students create individual 10 week timelines per goal set for that quarter.
 - iv. A calendar is provided for the students
 - v. These documents are due the next private meeting with the teacher.
 - vi. These documents are kept by both the student in Report 16 and by the teacher.

2. Junior Year

- a. The First Quarter Dissection of a Scientific Article (this is a different paper than the sophomore year paper.)
- b. The junior Vision Paper – due the first week in December.
- c. The junior Mid-term paper found in Report 16: examples included in the Teacher’s Manual Addenda.
- d. The juniors present their mid-term paper with PowerPoint to the class. If no results are present, the student should include graphs with “expected” results.
- e. The Juniors prepare a poster board by third marking period and present it to the class between third marking period and before the Symposium.
- f. *The first large group meeting of each new quarter is reserved for the activity “The Creation of the New Quarter’s Research Plan”:*
 - i. The students write a statement of what they have accomplished over the past quarter.
 - ii. The students create goals they wish to accomplish in the next quarter.
 - iii. The students create individual 10 week timelines per goal set for that quarter.
 - iv. A calendar is provided for the students
 - v. These documents are due the next private meeting with the teacher.
 - vi. These documents are kept by both the student in Report 16 and by the teacher.

3. Senior Year

- a. Each senior writes and presents his/her Intel paper in September/October to the entire group of sophomores, juniors, and seniors.
- b. By midyear, each senior creates and presents a research poster to the class.
- c. Seniors prepare PowerPoint presentations of their research.
- d. Seniors enter all competitions for the rest of the year.
- e. Seniors present at the BHHS Symposium
- f. Seniors submit a final copy of their research paper, both in hard copy and on disk or CD.

Figure 1. The Spiral Curriculum in the Authentic Science Research in the High School Program

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of Environmental Protection. Where ever their interests go, the students will go with their research. One of my students actually went to Washington State from New York to study chimpanzees and do research about them. The past year, that one young lady became a finalist for doing that work. So, every student works in a professional circle with a mentor.

JSGE: Professional researchers, scientists, and professors are busy people. How do you get them to volunteer?

Dr. Pavlica: Approximately 90% of all the requests that my students send out are honored by the professors. Here's how it works: It goes back to Maria Montessori's comment that common sense is often uncommon. A 10th-grade student during ninth-grade summer begins to create a topic she wants to study. By the end of October, that student pretty well knows what she wants to study—cancer, physics, butterflies.

I had a young lady who was a writer and her science research was a critical analysis of creative writing. That's not an oxymoron. She actually studied that topic where she identified words and phrases that appeared to indicate creative writing. Now this student is asked to collect 20, 30, 40, 50, 60, 70—I'm not kidding—articles off the Internet, print them, read them, write a summary, and ask two questions of each article she reads. Every 2 weeks, she meets privately with me in a 1-hour session. She talks to me about the 10 or 20 articles she has read and puts them in order—which article she likes best first to the one she liked least.

Now, the art of teaching comes into play because the student will often say, "I really love this topic" or "There's another topic that is mentioned here that sounds interesting." The second statement is significantly different, and the teacher must pick up on it and guide the student.

After 45 minutes of talking about these articles, I'll ask the student, "What do you think you want to do now?"

She will say, "Well, I think I need to know more about butterflies" or "I think I want to go in a new direction and focus on migration patterns."

So, that's the self-directed assignment. The student comes back 2 weeks later and says, "I think I know I want to study migratory patterns of monarch butterflies." Now, we have a topic that the student loves. It came from her.

Next step, we go to Web sites of various universities and various research centers to look up the area of her interest. If it's butterflies, then we look up entomology or lepidopterology. On the Web sites there may be 10, 15, 20 professors who are doing research in this area. The student clicks on every one of these professors and reads their biographies. The student begins to say, "I like Professor A, B, or C." The student then does a search on DIALOG. This a subscription service company from California that takes every scientific published article in the

world and within 30 days translates it into English and puts it into its data base. She searches for Professor B and finds out that he has published 67 times. The student then requests from DIALOG all of Professor B's publications in abstract form. DIALOG prints out all 67 abstracts and the journals they come from. The student reads the abstracts and decides she really likes a certain one. These abstracts are difficult for this 10th grader to read. The student then goes to a library—a college library, the New York public library—and gets the journals with the full article in it. The student can hardly understand these articles at first, but she knows that this is what she wants to study, so she persists and conquers the articles. The student now constructs an e-mail message to the potential mentor. The message is broken up into the following subsections:

Paragraph 1: The student talks about the strength of the program at Byram Hills High School.

Paragraph 2: The student writes about why she has a personal interest in the topic.

Paragraph 3: The student writes about her strengths, such as, "Since ninth grade, I have wanted to study butterflies. I have read 80 articles on the Internet about lepidopterary. I have found, Professor B, your name mentioned in seven of these articles." Then, the student says, "Professor B, I did an international search on you and found that you published 67 articles. In fact, Dr. B, I have all 67 of your abstracts and I have seven of your articles, which I really love. In particular. . ." Here the student lists the articles and publications.

Paragraph 4: The student writes, "Professor B, I would very much like to spend my next 3 years and 2 summers doing research on butterflies. I do very well in school in all my subjects, but more importantly I am hard-working, reliable, and I love butterflies. Professor B, it would be an honor for me if you would take time from your busy schedule so that I might learn from you and work with you on butterfly research."

Professor B has been flattered. His college students have not done what this high school student has done: found his articles, read them, found his e-mail, and sent him a highly structured, well-edited letter. Within a week, 80–90% of all e-mails get a hit. The professor says, "It was a pleasure to get a letter from a high school student such as you. I would be honored; I would be pleased to work with you." Some professors are located nearby in New York City. Others might be located on the West Coast. If the topic is one that lends itself to collaboration by e-mail, such as psychology or lepidopterology, then the mentor could be in California. If the topic is a hard science that requires hands-on and over-the-shoulder support from the mentor, such as DNA testing, then the mentor should be local, in our case New York City. That's how it works.

JSGE: What have teachers you have trained said about your program?

Dr. Pavlica: I remember a few years ago I was teaching a fellow teacher in the program. Most of the teachers are young and enthusiastic, and the program takes off very well in their schools. This one teacher I taught was 52 years old and 3 years away from retirement because he was tired of telling students what he was going to tell them, telling it to them, and then telling them what he told them and then giving them a test. He was tired of that; he was raising puppets in his classroom. So, this 52-year-old teacher took my course, and, after the training workshop was over, he came to me and said, "This is the best workshop I've ever taken in my life because it empowered me by giving me the vision, the skills, and the tools to go back into the classroom to do what I really wanted to do 30 years ago when I started teaching, which was to get students excited about learning, especially learning about science!" This teacher is now approaching 60 and is still teaching science research.

JSGE: Looking back, who influenced your career?

Dr. Pavlica: Yes, years ago I was a young teacher in a traditional school. The students were doing very well in my class because, like my friend the 52-year-old teacher, I too told them I was going to tell them, told it to them, then told them what I told them and they memorized it. They did well on regents and SAT exams. I had good discipline in my classroom, not a sound except when I asked a student to speak. That's when I suspected something was wrong with the picture.

I really knew something was wrong when one day the superintendent came into my class for an observation. That one period we were redoing a lab on genes in which we had chromosomes, crossing over, mitosis, and meiosis. The kids were explaining it to one another. They were saying, "No, it's this way!" "No, it's that way!"

The bell rang, students left, and I said to the superintendent, "Wasn't that a great class?"

He said, "There was a lot of confusion."

"I know. That's why it was so great—the questions, the challenges that were going on. And tomorrow we can continue this inquiry."

"Well I'm not really sure. There needs to be more order, more structure, more instruction from the teacher."

I quickly got my tenure the old-fashioned way and very quickly went to find out more about inquiry learning. At that point, I started to study Maria Montessori. I sat in on Maria Montessori classes. I went to Marymount College in Tarrytown where Maria Montessori's work was being taught. I read all of her books that were translated into English. She talks about "spontaneous explosions," where people—children—go from one level of knowledge to another of leaning abilities. That's the art of being a science research teacher: to know when to slow down the music for that student who is not at the next

level and when to speed it up for the other student who's at another level. So, I was influenced by the negativity that I saw in education that was being passed off as rigorous education, and I did not agree with that because it was simply memorization, and I was influenced by the work of Maria Montessori.

JSGE: Would you explain more about how the idea of "spontaneous explosion" influenced the development of your Science Research Program?

Dr. Pavlica: Children aged 3, 4, and 5 in Maria Montessori's little school in Italy would play games that were really teaching tools. She would use black and white rods to have the children build a pyramid structure to understand that two is twice the size of one and three is three times the size of one and so on. If she noticed that a student was not engaged in the structure building, but was playing choo-choo train with the rods instead, then she would say that the child was not at the level to achieve the purpose of that activity and would put that game away and then play another game at a lower level. The student would feel success at that level. When a student successfully accomplished the work at the appropriate level, there was a spontaneous explosion—a need, a desire to move to a higher level.

The Science Research Program is based on that principle of spontaneous explosion. There are activities that the students must go through in each of their senior, junior, and sophomore years. Some students accomplish the activities in 3 or 4 months, some students take a month or 2, some in 2 weeks. The time frame for accomplishing these tasks is not important.

Let me give you an analogy. I compare my students to different size glasses: a whiskey glass, a water glass, and a pitcher. As long as you have a whiskey glass that is filled to overflowing, the child is doing all that he or she can do. If you have a water glass that is filled to overflowing, the child is doing all that he or she can do. If you have a pitcher that is filled to overflowing, the child is doing all that he or she can do. So, in my class, I have whiskey glasses, water glasses, and pitchers all filled to the top and overflowing. That is the teacher's role: to differentiate by making sure that each child is filled to the top and overflowing by having the student do the appropriate activities. The children do not risk failure unless there is a reasonable chance of success. It is the teacher's role in science research to prepare the students in advance so that they are accomplishing the skills to be successful.

JSGE: Do you still get excited about the program?

Dr. Pavlica: Last week, two students were sitting at my door waiting for me to come in at 7:30 a.m. When they saw me,

they jumped up and yelled, “Dr. P, Dr. P, I got a mentor, I got a mentor! My mentor e-mailed me and said he wants to work with me.” And that’s what happens almost every day. Miracle after miracle after miracle, and all you’re doing is what a band leader does: keeps time, raises his hand, and everyone plays his or her instrument according to their talents.

JSGE: Dr. Pavlica, one last question: What are you going to do next?

Dr. Pavlica: Well, it’s my goal to bring science research to every high school in the country. Just like every school in the country needs a basketball team or a football team or a theater group, they need a science research course. It’s an elective program that should be placed in every school, whether it’s urban, rural, or suburban. In fact, the program does equally well in urban and rural and suburban settings. So, hopefully, my program will get the attention of the Secretary of Education in Washington, as well as the superintendents of schools throughout the country.