

Paul Werbos: Can the NSF Return to Its Former Glory?

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Robert J. Marks:

How does the NSF steer research in artificial intelligence? We continue our conversation with Dr. Paul Werbos today on Mind Matters News. Greetings, I am your awesome host, Robert J. Marks. We've been talking to Paul Werbos about the National Science Foundation and our time was used up last podcast, so I want to continue along that line. Dr. Werbos is the inventor of error backpropagation, and he served 30 years as a program director at NSF.

Robert J. Marks:

And during this time, Dr. Werbos steered NSF's funding and much of its machine intelligence research. And he's our guest today on Mind Matters News. Welcome, Paul, I should say, first of all, and welcome you. You know, you mentioned a couple of podcasts ago that if somebody has the money, you have to dance to their tune, and that's frustrating sometimes.

Robert J. Marks:

And we have that to a degree at NSF. I think that steering it is important. So research agendas are often dictated by the National Science Foundation where you spent 30 years as a program director. To what degree does NSF consider innovative proposals off their radar and don't fit into a pre-defined program? And is there any thought of tuning this trade-off to get the biggest impact for our federal bucks?

Paul Werbos:

Since I'm usually criticizing people, let me change my pattern and stress the positive, because sometimes that's the right thing. I am so grateful that I had those 30 years to work at NSF in part of the period of peak creativity in that building. I even remember a day in 2014 when I knew I was going to go in the next year, I remember looking around me in that building in Boston saying, this is the greatest breaking up, as I say it.

Paul Werbos:

This is the greatest true temple of truth in the history of humanity.

Robert J. Marks:

Wow, that's quite a statement.

Paul Werbos:

That was how I felt and I believe it was true, I hope we can do better. There are special areas where they're better, but NSF, certainly focused on its mission, I believe was the greatest temple of truth in the history of humanity, and I'm so grateful that I was able to learn all I could in those surroundings and it has a lot to do with innovation. The way the NSF became so great was because of a guy named Bush.

Robert J. Marks:

Okay, junior or senior?

Paul Werbos:

Vannevar Bush. He was at MIT, I forget whether it was only a professor or also a dean. He was high up at MIT in the old days.

Robert J. Marks:

So this was not a president, this was somebody else.

Paul Werbos:

Yeah, it was not a president, it was before me - be a great president. But surely after World War II, there were people who really said, "You know, the United States really needs to develop real science, we shouldn't depend only on Germany for God's sake." And so Vannevar Bush, apparently he was closer to our neural network world than I knew until a couple of years ago, he was not so far from our community.

Paul Werbos:

And Vannevar Bush put together a document, a manifesto, the endless frontier. And if you go to the NSF webpage today, nsf.gov and search on the endless frontier Vannevar Bush, you can still find it. And I'm really glad it's there because that corporate culture, that Bible of NSF was really crucial to being an honest pursuer of truth, which is not what you always get.

Robert J. Marks:

Could you spell his first name? Vanameer?

Paul Werbos:

Vannevar, V-A-N-N-E-V-A-R. Vannevar Bush. And in recent years I've been talking to UN people saying, "You've got to read it, you've got to reinvent this. We need this corporate culture. What you got at the UN is not working. We need a culture that works. Vannevar Bush had a really good manifesto on how to do it." We have learned a little bit, a lot of people at NSF when I was there were working very hard on how to do better, because a big part of the corporate culture was you are not following, it's not the Tom Wood, it's not a Book of Rules from ancient times. It's a living guideline and every year NSF would really think hard on how can we do the job better.

Paul Werbos:

That was true for my whole tenure there, and there were different approaches, different philosophies. Again, from 1988 to 2015, I saw a lot of different things, but until about 2014, maybe 2013, we were following Vannevar Bush's corporate culture and it was the greatest temporal truth there ever was.

Robert J. Marks:

What was the official role or office of Bush at this time?

Paul Werbos:

I think he was the first director.

Robert J. Marks:

First director, okay. And I believe it started, didn't John F. Kennedy start the NSF in response to Russia's Sputnik?

Paul Werbos:

No.

Robert J. Marks:

No?

Paul Werbos:

No, no, no. That was later. Kennedy was later. This was like after World War II.

Robert J. Marks:

I see, okay, go ahead please.

Paul Werbos:

At least I hope I'm not that mixed up. I went to work there at 1988, so I can't say I really know the history so personally before 1988.

Robert J. Marks:

Okay.

Paul Werbos:

And a major part of his role was innovation. And when I was there, I was allowed to follow Vannevar Bush's approach. And part of the approach was, I didn't know some economics, economics, I do have a couple degrees in that. And a major part of economics is what do you do with high-risk research which cannot be totally funded by just one player, it has value because it cuts across and has value across many people, and high-risk research is especially suitable for government funding.

Paul Werbos:

And I remember people used to ask, "What is the role of the government? Shouldn't the private sector do everything?" And the best answer that said it should be doing something was an answer that said, "Well, there are externalities. There is high-risk research that you can only do on a kind of a pooled basis."

Paul Werbos:

So NSF was the source of money of last resource for high-risk projects, and that was really critical. Now the problem is, there's some way-out ideas that are so way out, it's difficult to do justice to them. And for a long time, we had many debates on how do you do justice to really out of the box innovation? How do you do justice to fundamental new directions? And I would say from the day they hired me to a year before I left, that was sort of my personal responsibility was to be especially vigilant that we not lose these more aggressive opportunities. I could talk about that because we were very specific.

Paul Werbos:

They hired me to run two programs in 1988, '89. One of them was the neural network program, and the other one was emerging technologies initiation. A special cross-cutting program, designed to fund new emerging areas that wouldn't be funded under the conventional framework.

Robert J. Marks:

So that's the response to my question, that was the program that allowed people with innovative ideas to propose for funding to the National Science Foundation.

Paul Werbos:

Yeah.

Robert J. Marks:

Great.

Paul Werbos:

And by the way, the guy who set it up in the first place was a double E, double degree of law and electrical engineering, my first boss. He ran a whole division and I was brought in to run the program, but it changed through time. They've changed somewhat how they do that, but innovation has always been a major issue. I will never forget the day when the deputy director of engineering said, "Paul, when the really weird, hard to understand things come in - like the guy really, it sounds like perpetual motion and it looks like there's math, but we can't believe it.

Paul Werbos:

The really crazy stuff, we want you to handle the really crazy stuff." And so that was a side job I had for a few years. If it was really, really strange, they would let me try to figure it out. And that was very entertaining.

Robert J. Marks:

You mentioned your tenure at NSF, NSF was in your own words, the temple of truth. What's happened since your retirement? Do you have any forecasts? Well, do you have any thoughts about the way the NSF has been operating since then? Or do you know? I mean, you've been out of the loop.

Paul Werbos:

No, no, I know, I know, I don't want to get too far into all of the details. I can say when I decided to retire, I remember speaking to a couple of administrative personnel about it, and I still remember one woman who looked like a character in the Beetlejuice movie, I don't know if you ever saw that movie.

Robert J. Marks:

I've seen pieces of it, I couldn't sit through the whole thing, but was she one of these zombie ghost sort of people?

Paul Werbos:

Oh yeah, yeah. There's a scene in Beetlejuice where the guy has just died and now he's in the other world and what are they going to do with him? And they put him before a desk and there's this weird

clerk with orange hair who is, "Ah, next," he's like, "Oh my God, I just died. The guy next to me is a pygmy with a shrunken head." Yeah, yeah. Next.

Paul Werbos:

And it was a lot like that, it was really weird what was happening that year. I think I'm pretty sure it started in 2013, and I was sort of halfway through the wave of stuff that happened. And I talked to a lot of people about what was happening and I'm tempted to name names but I can say that there was a debate I had with a close friend who was high up in the management.

Paul Werbos:

And I said, "We both agree something very bad has happened. We both agree there is this following stuff going on, but we don't know who's responsible. They're not telling us who they are." And there was one theory that it was Obama, and there was another theory that it was a guy in the Republican Party. And what can we say? There were different theories.

Paul Werbos:

I went to a university where one of the deans had heard about weird things, he said, "The people we work with, think it was the Gestapo. Are you Jewish?" I said, "No, I'm not Jewish." "Are you sure you're not Jewish? He told us the Gestapo came." I said, "No, no, it wasn't that."

Robert J. Marks:

We talked about fake news.

Paul Werbos:

But my theory, and it gets to be a theory, is that until about 2013, the deans and the American Physical Society were very much had us under their protection.

Robert J. Marks:

Now, what do you mean by the deans? Do you mean the deans of the major universities or what?

Paul Werbos:

Yeah, yeah, yeah. The universities had tremendous power at NSF, and I'm sure they still are listened to, but it was basically the APS and the deans between them, they could protect us from the worst evils of the world. And where are the worst evils of the world? My theory is that money in politics in Washington, DC, twisted to serve special interests and special stakeholder friends.

Paul Werbos:

I have seen that work in many government agencies. After all, I wasn't DOE2, I interacted with a lot of agencies. My feeling is it was a shift to the stakeholders. And in 2014, in fact, I was invited to two meetings with stakeholders with very large financial commitments and there are things they wanted from us, very different from what NSF was giving them in the past. And when I looked at what they wanted me to give them, I said, "Okay, better I should retire than do what these guys want me to do."

Robert J. Marks:

My goodness, I do remember reading a lot that a lot of the policies of NSF were painted by political issues, which is kind of sad.

Paul Werbos:

It was a big shift, it was a massive shift. And it's not that NSF ignored politics. NSF broader impact is about serving society in general. Joe Bordogna was a pioneer of making people pay attention to broader impact, and that's good.

Robert J. Marks:

Okay. Who is Joe Bordogna?

Paul Werbos:

Oh, he's another double E.

Robert J. Marks:

I should know him then. I'm a double E, so I don't though.

Paul Werbos:

Well, you should have known him. He was a critical force in the history of NSF, and I have a lot of contact with him, but what stories do I not tell about Joe Bordogna? But Joe Bordogna defended the concept of broader benefit. He had a vision of, we should fund work which pushes the frontier, but it's also serving the larger needs of society in ways that others can't, and there's also the human development, I guess those were the three real priorities.

Robert J. Marks:

So it sounds like you're saying that the status of NSF as the temple of truth when you were there has developed to the point where that's no longer true. Have you seen any development since then?

Paul Werbos:

Joe Bordogna was consistent with the temple of truth. It was later people, and as I say, we argued over who it is, they were very stealthy. And I got a lot of clues but the question is, will we build back better if you forgive the expression?

Robert J. Marks:

I forgive you, Paul.

Paul Werbos:

I have a foot on both sides and when I was in NSF, I did my damndest to have a foot on both sides.

Robert J. Marks:

You have to. I mean, that's part of being a part of that organization. You try to remain apolitical as much as possible.

Paul Werbos:

Yeah. And it was I think probably part of the Bible, according to Vannevar Bush, that we want to be trustworthy and reliable for leaders in both parties and whenever they try to do good for the country, we should always try to help them do good for the country. And they may try to do good for the country in different ways. But if they're trying to do good for the country, we should try to make sure it works out for the best and that they're happy and we're happy and everybody's happy. And we don't want to take sides in political wars, and I took that to heart very, very deeply, I really try to follow that.

Robert J. Marks:

Well, I think you're mandated to do that by your job description, right?

Paul Werbos:

Yeah.

Robert J. Marks:

I mean, it probably says in there, you can't be political, probably just like people in the military, they can't take sides, political sides.

Paul Werbos:

Yeah. However, in the era of stakeholder politics, it gets to be a little dicey, because if a big stakeholder tends to be associated with one party and not the other... I'm glad I don't have to deal with that as much, but I'm hoping they will build back better. And I see happy signs and I see bad signs, but what worries me the most is it took so damn much work to make it the temple of truth that it was. It's not enough to have an ordinary level of competence.

Paul Werbos:

And so there's some good intentions, but there are also some big stakeholders with money still in operation in both political parties. And the role of these big stakeholder money things and the difficulty of reconstructing what we used to have. I'm hopeful, I do what I can to help if I can, but it's a hell of a challenge.

Robert J. Marks:

One of the interesting things historically is the involvement of big tech in technical development. I think of the heydays of Bell Labs. Now, Bell Labs who had incredible advances, one of the things I'm really interested in and I teach a course in it, is information theory that came from Bell Labs. Many inventions came from Bell Labs, but Bell Labs folded because somebody said, "In order for a country to have a poet, the country has to be rich." And I think the Bell Labs began to lose that after divestiture.

Robert J. Marks:

But now we're seeing more involvement, especially in artificial intelligence with people like Amazon and Google. Now Bell Labs in my knowledge was always apolitical. We see a lot of political things happening with Amazon and Google. And they're making great progress in places like deep learning. In fact, they're even making their AI software available to anybody who wants it.

Robert J. Marks:

Google, for example, has made something called TensorFlow neural network training available to all, I use it with my graduate students. And I have heard, I don't know if this is true, but I've heard that Google's research budget, it's currently larger than NSF. If that's true, that's really interesting.

Paul Werbos:

Yeah. So I have been following those things. In fact, my younger daughter just recently retired from Google and I have been in touch with some of those kind of people. After all Sergey Brin was the guy who really brought us back to neural networks. But on the other hand, Sergey Brin has other roles in the government now and world politics is tricky.

Robert J. Marks:

Well, thank you, Paul. We've been talking to Paul Werbos, inventor of the most commonly used technique to train artificial neural networks in the world, error backpropagation. He's also a former program director at NSF. Thanks for listening. Until next time on Mind Matters News, be of good cheer.

Announcer:

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