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Conversation with a Prominent Propagator: Frank Vahid

Encouraging faculty to adopt transformative teaching practices in computer science (CS) undergraduate education requires sustained, intentional planning and effort. This article is the next installment in our series of interviews with *prominent propagators*: members of the CS education community who have successfully spread pedagogical or curricular innovations [2–4]. The goal is to capture knowledge and experiences that others can use to propagate their own teaching projects.

In this article, we interviewed Frank Vahid, Co-Founder and Chief Learning Officer of zyBooks.com and Professor of Computer Science and Engineering at University of California Riverside (UCR). zyBooks [13] uses web-based, interactive learning content to replace traditional college textbooks and homework. Frank's research centers on learning methods to improve lower-division education in CS and STEM [1, 5–9], and embedded systems software and hardware [10–12].

Below are highlights of the interview, which ran approximately an hour. The transcript has been edited for clarity and style.

Q: TELL US ABOUT ZYBOOKS AND HOW IT CAME TO BE.

FV: I was the undergraduate advisor for our computer science program back in the late '90s, early 2000s. I was doing some analysis and discovered that we were losing 30% to 50% of our majors in the first year. It wasn't just a problem at my university, it was a nationwide problem. I know our students are mostly first-generation students, low-income students, and underrepresented minorities, and it was just a tragedy to me



Frank Vahid

to see that they set this great goal for themselves, they overcame huge hurdles just to get to college, and then we were losing them in the first year. That was the impetus. I made a big shift in my career and said, "I'm going to see if I can tackle this problem."

My entire time as a student, I kept thinking, this is not the way to learn. I mean, this is just so inefficient. And then as professors, we start learning that lectures aren't very effective. Even just reading isn't necessarily the best way to learn a skill-based discipline. You can't learn piano just by reading about piano or watching somebody play piano on stage. You have to do it, and you need lots of feedback.

I had written a couple books in the early 2000s and I was trying to get the publisher to use the web because the web was growing. They just didn't really seem to know how to do it. At some point I started tinkering with trying to create learning content using the web, and eventually said, "We should get rid of the book and just have the learning be on the web, because then you can give the immediate feedback that students need."

Q: WHAT WERE THE STEPS YOU TOOK TO GO FROM "I HAVE MY OWN EBOOKS THAT I'M USING IN MY CLASSES" TO "I'M MAKING A PRODUCT THAT ANYBODY CAN USE"?

FV: There were a bunch of steps along the way. The first step was, for the books that I already had, the publishers had somebody create PowerPoint slides. And I said, "These need to be animated." Animations are so powerful. We homeschooled our kids and every time my kids had a question about something, if I could find an animation online, I knew that learning was going to be smooth. So, I started animating those slides and I ended up doing 600 animated slides for my digital design book myself. That was the first step. Then for programming, it was, "Hey, you have to be coding and you need immediate feedback on the coding." So, I started developing a tool where you could learn content. You could just program in the window and it would tell you whether it was right or wrong.

I actually got an NSF grant back in 2008, and the idea was to create an OER: open education resource. And it was doing well, actually. We had probably a dozen schools using it and many hundreds—if not thousands—of users, but I quickly realized I needed professionals to manage this. This is not something that I can just rotate master's and PhD students through if I really want this to be a quality learning experience for the students. And so, in 2012, I finally decided this needs to be a company with full-time professionals.

Q: WHAT'S YOUR MOTIVATION FOR PROPAGATING ZYBOOKS?

FV: I talked to a department chair at a math department once about improving the pass rates of their intro courses. The

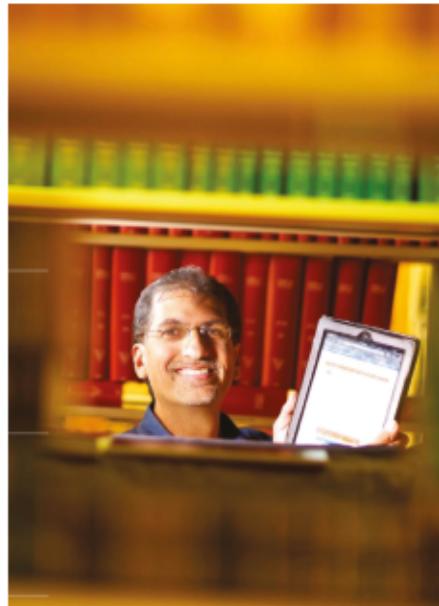
first thing he said to me was, "Frank. We fail 30% of our students, and we do not want to lower that because we want to maintain quality." Their definition of quality was failing 30% of the students. So, my "evil plan" is to change how universities teach their students, especially their freshmen and their sophomores, and really get them to adopt what's known about good teaching: interactive, active lectures, Peer Instruction. Lots of formative assessment, lots of feedback, positive supportive environments.

Q: HOW DO YOU GET THE WORD OUT TO PEOPLE AND CONVINCE INSTRUCTORS THAT THIS IS THE RIGHT THING TO BE USING IN THEIR CLASS?

FV: Thank goodness for my co-founder Smita Bakshi. I was thinking, "If it's good, it'll spread." It just doesn't work like that. She's like "Frank, we need a sales team and a marketing team." To me, sales was kind of a "four letter word," you know what I mean? Especially being in academia, you pictured a "pushy car salesman" and stuff. One of the greatest educations that I've had is that sales can be a very noble field. If they have something that can help somebody else, getting that person to pay attention and to understand how they can be helped by this thing is a very challenging task. It takes a lot of skill and a lot of talent. So, she built a sales team. Over time, I have come to have tremendous respect for the art and the skill and the patience that these people have because we faculty are a tough crowd. The sales people just do what they can to politely get it in front of people so they can see what it is and make an informed decision. And honestly, once people see it, we have a pretty good conversion rate.

Q: HOW IS ZYBOOKS DIFFERENT FROM A TEXTBOOK?

FV: A lot of faculty will look at our material and say, "This looks light" because they're used to measuring the quality of a book in terms of how many pages are dedicated to their favorite subject. "I want them to cover this particular sorting algorithm. This book only has two pages on it, but this [other] book has 14 pages on it." Whereas those two pages might be better than 14 pages, because they include an animation



that illustrates the concept and a bunch of questions that help the student really understand it.

We've interviewed students and they use the term "wall of text," for example, "When I see a wall of text, my eyes glaze over." We can study exactly what students are doing in our content, and we've seen that if you write 200 words or less, students will mostly read every word. But as soon as you start going over 200 words, you start to see a diminishing amount of attention. And by the time you get to 400, 600, 800 words, they're spending less time reading 800 words than they were reading the 200 words. I don't mean they're reading at a faster rate. They're actually spending less time [8]. And by the way, I don't think that's just today's student. I think that's going back to when I was a student as well.

Q: SO HOW ARE YOU THINKING ABOUT CONVINCING PROFESSORS THAT TWO PAGES ARE ACTUALLY MORE EFFECTIVE THAN 14 PAGES?

FV: It's one of the biggest challenges we have. Roman Lysecky and I worked on all the authoring guidelines within the company. And we say, "You always put the student first. Instructors are a close second, but the student always comes first." You always write for the student and then you need to have the courage to explain to the instructors why this is better.

One of the earliest things we did back in 2013–2014 is we started doing research studies. We did a controlled study where we took 250 students and half of them got a normal textbook—the number one selling textbook at the time. I think it was Java. And then half of them got this interactive content. We gave them a pretest and a post-test. And the students who received the interactive content learned more. They did better on that post-test. But interestingly, the students who bombed the pretest did dramatically better on the post-test than the students who had the regular book, 64% improvement. And we brought them up to the average [6]. That was exciting. Because those were the students who are most likely to have those low grades and end up dropping out of the major in that freshman year perhaps. And so, we were able to reach out to them. That was really exciting. So, we show this data to faculty, and it seems to help.

Q: HOW HELPFUL IS THAT RESEARCH IN TERMS OF CONVINCING PEOPLE?

FV: It's very helpful. And the way I know is that our sales team, many of whom are highly experienced, have worked for big publishers in the past. Many of them have 20, 30 years under their belt and they said they've never sold anything like this because this one is actually backed by real research and is basically started by professors. So, they're telling me that it's still not easy, but it's easier because they have that data.

Another study that we did in the early days was that we found very mature courses and the only change they made was switching to this interactive textbook. And these were the same teacher. They've been teaching the class for years. They didn't make any major changes to the course, but they made this one change. We found four courses that did that, and all the instructors said the same thing: "The students are now coming to class prepared, whereas before it was like pulling teeth trying to get them to read before class. So, they're actually coming and they're getting more out of the lecture. They're asking more interesting questions. I'm starting to flip my class. I didn't

Conversation with a Prominent Propagator: Frank Vahid

even intend to flip my class, but it's just naturally becoming flipped. I'm starting to do Peer Instruction," which as you guys probably know is one of the most powerful techniques we can use in our field to get students learning in lectures, to let them talk to each other more [7].

Giving this data to instructors helps, but it's not a slam dunk. I'll tell you a story. I was giving a talk on this, and I was explaining exactly what I've explained to you so far. And a professor interrupted me early in the talk and said, "Excuse me, are you saying that it's part of my job to help the students better learn this content?" And I said, "Yeah." And he said, "What's next? Shall I change their diapers?" So, I realize that not everybody in CS education has the same attitude that I think we all do. The attitudes that are resisting us are kind of extreme, but not everyone agrees.

Q: YOU'RE THE FIRST PERSON WE'VE INTERVIEWED WHO CREATED A COMPANY TO PROPAGATE THEIR INNOVATION. HOW DO YOU FEEL THAT HAS BOTH HELPED AND MAYBE HINDERED YOUR EFFORTS TO GET ZYBOOKS ADOPTED?

FV: It has helped because we currently have 150 professionals dedicated to this full-time. Practically half of them are content people. We have a bunch of in-house authors. We have a bunch of professors. Then we have a bunch of people just working on that platform, making sure it's always up. Our platform has been down a total of maybe a couple hours in like 10 years now. And that's not easy to do because the web is constantly changing. Chrome pushes an update and all of a sudden something doesn't work anymore. So, it has helped in the sense that we have a robust product, a lot of uptime, a lot of features. People often don't understand how hard it is to build something like this. It's millions of dollars to build an interactive product that really works robustly across platforms and that handles accessibility and security. It's a very complex operation. So having a company really helped in that sense. We can build the product in a robust way.

It has hurt because "company" is another four-letter word in academia. It's

PARTICIPATION ACTIVITY

3.6.1: Using multi-branch if-else for detecting ranges with gaps: Movie ticket prices.

1 2 3 4 ► 2x speed

```
#include <iostream>
using namespace std;

int main() {
    int userAge;
    int movieTicketPrice;

    cout << "Enter your age: ";
    cin >> userAge;

    if (userAge <= 12) { // Age 12 and under
        cout << "Child ticket discount." << endl;
        movieTicketPrice = 11;
    }
    else if (userAge >= 65) { // Age 65 and older
        cout << "Senior ticket discount." << endl;
        movieTicketPrice = 12;
    }
    else { // All other ages
        movieTicketPrice = 14;
    }

    cout << "Movie ticket price: " << movieTicketPrice << endl;
    return 0;
}
```

Memory

99	18	userAge
97		movieTicketPrice
98		

Enter your age: 67
Senior ticket discount.
Movie ticket price: \$12

Enter your age: 19

67 <= 12 X
67 >= 65 ✓

19 <= 12 X
19 >= 65 X

If the user's age falls between the gap of 12 and 65 (13 to 64), the else branch executes and the ticket price is \$14, the most expensive price.

Captions ▾

Feedback?

PARTICIPATION ACTIVITY

3.6.2: Detecting ranges with gaps and multi-branch if-else.

Select the correct answers below.

- In the animation above, what is the age range for a child ticket discount?
 - 0 - 12
 - less than 13
 - less than 11
- In the animation above, what is the age range for a senior ticket discount?
 - 65 or more
 - 66 or more
 - 13 - 64

Correct

The age range must be less than or equal to 12, so any number that is less than 13 is valid.

Incorrect

The age range must be greater than or equal to 65, which includes 65. So any number that is 65 or greater is valid.

kind of viewed like all companies have bad intentions.

Q: WAS THERE A MOMENT WHEN YOU REALIZED THAT ZYBOOKS WAS GOING TO BE A BIG DEAL?

FV: Yeah. SIGCSE TS 2013. We incorporated in 2012 in the spring, and I wrote the first zyBook in C++. We used it at my university in the fall. And then we went to SIGCSE TS in March of the following year, and we had a booth. It was me and Smita, a handful of students, part-timers, and things. A lot of the stuff Smita and I just paid out of our pocket. We went to Target in the city and bought a TV and put in the booth. We looked around and the other publishers had maybe one person at their booth, and we had 20, 30 people just surrounding us. And the keynote speaker came up and said, "I heard I need to come to this booth." We

knew that there was a need for this, but we didn't realize there was such a need for it. It took off. People immediately asked, "Do you have Java? I want Java." "Do you have Python? I want Python." "Do you have Discrete Math? I need Discrete Math." They just started telling us what we needed to build. And we built them.

Q: HAS HAVING TO SUPPORT ALL THOSE DIFFERENT LANGUAGES BEEN A CHALLENGE?

FV: Yeah. Everything we do is times four: C, C++, Java, Python. We want to come up with a set of example labs that can go along with the book times four. So, we make 60 labs times four. That's been a challenge. I kind of wish historically that the community didn't depart into these different languages. I think it's split the community a bit, but we have to deal with what the situation is.

You're the first person we've interviewed who created a company to propagate their innovation. How do you feel that has both helped and maybe hindered your efforts to get zyBooks adopted?

Q: DO YOU COLLECT USER FEEDBACK ABOUT THE SYSTEM ITSELF?

FV: From the very beginning, our philosophy has been one of continual improvement. We are not done. We're never done. There's always room to improve. So, we put these feedback buttons all throughout the content and we set up a whole process.

We are constantly soliciting feedback from the students. Our feedback buttons go to our support agents. We get lots of places where the students will say, "This is a little confusing. I don't understand this" or "Your system is broken: I'm clearly typing the right code and you're not accepting it. What's wrong with you?" And we immediately look and say, "Do we need to fix the content?" Most of the time the system's not broken, and the student is wrong, but we look and say, "Okay, what could we do to better instruct them before they get to that point so that they don't make that mistake?" Or "What feedback could we give them in real time so that they immediately realize their mistake?" We eliminate issues as quickly as possible. My philosophy is no more than one person should ever see an error in our content. They report it, we fix it, done. And every week we keep doing that, it's like a whack-a-mole. Every week there's something and we push it down and then next week there's going to be something else.

In terms of instructors, the most common unsatisfied instructor is one who wants us to add more features. Like, "Hey, I know that you could just make all your examples such that the curly brace either starts on the same line or starts on the next line. So why don't you just build that in as a flag, and I can select that flag?" But when you look at all the other feature requests

that all the other instructors have, you end up creating a monstrosity of a platform. And so, one of our biggest challenges is to keep it simple so that it's usable, and so that you don't need a massive instructor's manual and that it doesn't have all these bugs. Just simple, clean. Some faculty get a little annoyed that they can't have features that they want. We're always listening, and we do add features, but we have to be really, really careful about how we add them.

Q: WHAT ADVICE WOULD YOU GIVE TO SOMEONE WHO HAS SOMETHING THEY'D CREATED THAT THEY WANTED OTHER PEOPLE TO ADOPT?

FV: The landscape is littered with great ideas that fizzled out. It's not enough to have a good idea. The execution of it is really important and that requires a stream of revenue, not a one-time infusion but a stream, usually. Getting new users requires strategic ways of getting people's attention, which is hard. And then the third thing I would say is just keep it simple. Whatever your idea is, it should be understandable quickly, and it should be usable quickly with not a lot of set up. Even if you don't have all the bells and whistles and all the features, that simplicity will make a big difference. ♦

References

1. Allen, J.M., Vahid, F., Downey, K. and Edgcomb, A.D. Weekly Programs in a CS1 Class: Experiences with Auto-graded Many-small Programs (MSP). 2018 *ASEE Annual Conference & Exposition* (Salt Lake City, UT, USA, 2018).
2. Bunde, D.P., Butler, Z., Hovey, C.L. and Taylor, C. CONVERSATIONS: Conversation with a prominent propagator: Helen Hu. *ACM Inroads*. 13, 3 (2022), 6–9. DOI:<https://doi.org/10.1145/3549546>.
3. Bunde, D.P., Butler, Z., Hovey, C.L. and Taylor, C. CONVERSATIONS: Conversations with a prominent propagator: Barbara Ericson. *ACM Inroads*. 14, 1 (2023), 16–1 DOI:<https://doi.org/10.1145/3583091>.
4. Bunde, D.P., Butler, Z., Hovey, C.L. and Taylor, C. CONVERSATIONS: Conversations with a prominent

propagator: Beth Simon. *ACM Inroads*. 13, 4 (2022), 9–12. DOI:<https://doi.org/10.1145/3571090>.

5. Edgcomb, A., Vahid, F., Lysecky, R. and Lysecky, S. Getting Students to Earnestly Do Reading, Studying, and Homework in an Introductory Programming Class. *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education* (Seattle, WA, USA. New York, NY, USA, 2017), 171–176.
6. Edgcomb, A.D. and Vahid, F. 2014. Effectiveness of Online Textbooks vs. Interactive Web-Native Content. *2014 ASEE Annual Conference & Exposition* (Indianapolis, IN, USA, 2014), 24.460.1–24.460.10.
7. Edgcomb, A.D., Vahid, F., Lysecky, R., Knoesen, A., Amirtharajah, R. and Dorf, M.L. Student Performance Improvement using Interactive Textbooks: A Three-University Cross-Semester Analysis. (2015), 26.1423.1–26.1423.17.
8. Gordon, C.L., Lysecky, R. and Vahid, F. Less Is More: Students Skim Lengthy Online Textbooks. *IEEE Transactions on Education*. (2022), 1–7. DOI:<https://doi.org/10.1109/TE2022.3199651>.
9. Vahid, F., Downey, K., Pang, A. and Gordon, C. Impact of Several Low-Effort Cheating-Reduction Methods in a CS1 Class. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education* (New York, NY, USA, 2023), 486–492.
10. Vahid, F. and Givargis, T. *Embedded System Design: A Unified Hardware/Software Introduction*. (Wiley, 2011).
11. Vahid, F., Givargis, T. and Lysecky, R. A Pattern Recognition Framework for Embedded Systems. *ASEE Computers in Education Journal*. January (2020).
12. Vahid, F., Givargis, T. and Miller, B. *Programming Embedded Systems*. zyBooks, a Wiley brand.
13. zyBooks: <https://www.zybooks.com/>. Accessed: 2023 Feb 24.



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