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Teaching Philosophy: Theoretical Computer Science, Practical Real World Change

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1 Introduction: What is a Teaching Philosophy?

Why be an educator? The answer to this simply stated, yet profoundly cardinal query is a *teaching philosophy*, an expression of one's key motivation in joining fellow educators in creating the next generation of scientists, artisans, and citizens of the world. To answer the question, I'll explain my core objectives as an educator, my passion for teaching in my field of theoretical computer science and mathematics, my specific approaches to teaching, and measures of assessment.

2 General Philosophy: Why Become an Educator at All?

To explore a reasonable standard of general educational objectives, one must first consider the near universal transformation undertaken by education during the Enlightenment in Europe. Preenlightenment, scarcely the male nobles of the population received any reasonably form of education, and even then mired in superstition and religious fanaticism. Postenlightenment offered education based more in the scientific method to many more classes, exploding literacy rates throughout Europe.[1] Guiding this near universal adoption of an evolved education system are egalitarian principles of the Enlightenment: education should

- be available to all in society,
- equip students with the capacity to learn and question according to the scientific method,
- preserve past knowledge for posterity, and
- create future leaders in education, science, the arts, and technology to better civilization.[2]

Though the Enlightenment realized only some of the above, I believe nevertheless that these categorical imperatives are not only possible, but sufficient (and maybe necessary) for species survival. That is, implicit in these aims is that educators are not only the guardians of culture and custodians of science, but as arbiter to often capricious, undemocratic policy compelled by powerful institutions.

2.1 Activist

The first of the above objectives requires the educator to be an activist; though anyone can be an activist, membership in the educational elite confers incredible freedom and advantage, and thus, by any reasonable moral standard, confers comparable responsibility. Education remains largely the boon of the privileged throughout the western world, so, again, by utilitarian standards, the elites ought expand that boon to the marginalized classes. Reinforcing this model, elite education often serves elite interests, and thus offers mostly elite perspectives. Renowned educator Paulo Freire's critical pedagogy[3] requires acquainting privileged sectors with the perspectives of the marginalized and oppressed, essential in expanding education into domains largely ignored by elite institutions. In fact, Freire argues that even disciplines boasting (often inaccurately) of a less adulterated political status contribute to the problem. He writes

"there neither is, nor has ever been, an educational practice in zero space-time... neutral in the sense of being committed only to preponderantly abstract, intangible ideas..."[4]

For example, a mathematician can study Srinivasa Ramanujan's incredible insights into number theory while recognizing how the crippling poverty of India imposed by British imperialists significantly shortened his memorable, but

[1]Kurtz, Paul, Madigan, Timothy J., Ed. 1994. "Challenges to the Enlightenment". New York: Prometheus Books.

[2]Chomsky, Noam. Presented at the Learning Without Frontiers Conference - Jan 25th 2012.

[3]Freire, Paulo. *The Pedagogy of the Oppressed.* New York: Continuum, 2007.

[4]Freire, Paulo and Ana Maria Araujo Freire. *EPZ Pedagogy of Hope: Reliving Pedagogy of the Oppressed*, p. 65, Continuum Publishing Company.

brief life. A theoretical computer scientist can study Alan Turing's ground-breaking research into the nature of computation while recognizing the persecution he, like Oscar Wilde before him, suffered for his homosexuality. The history of science is replete with such examples, not to mention the broader ideological framework whose features includes inextricable links between technology and conquest. Expanding education to include those marginalized by western society necessitates recognition of the very existence of the oppressed.

We as educators can learn how to expand access to education not just through our direct institutional influence but in organizing with other educators and popular movements, both elite, such as UNESCO[5], and marginalized, such as third world solidarity and indigeneous popular movements pressing for greater equality.

Also, the educator must adopt a plastic and dynamic teaching style, as one must flex the material frequently to reach the student audience. In particular, meeting with students outside of prescribed lectures is key in encouraging and cultivating their individual interests in the material. Critical thinking in mathematics and theoretical computer science, to me, necessitates questioning old and constructing new paradigms for understanding. In my experience, I find this happens most effectively when the student exhibits high interest in the topic. I personally find this experience to be among the more rewarding as an educator.

2.2 Scientist

The second of the objectives requires the educator to be a master scientist/artisan, treating students as apprenticed scientists and artisans. Freire's work contrasts the "banking model," or "empty vessel model" of teaching[6] with a more active, engaged learning process, very much in keeping with tenets of progressive education founded by John Dewey. In teaching students to generate good science/arts, we as educators must encourage exploration. Laura Overstreet, a developmental psychology professor of mine, once said that raising children requires teaching them to be adults, not children. Similarly, I feel that raising future scientists and artisans requires teaching them to become scientists and artisans, not simply empty vessels waiting passively to be filled. Science, after all, is a participatory, collaborative endeavor, described by Chomsky as

"...tentative, exploratory, questioning, largely learned by doing. One of the world's leading physicists was famous for opening his introductory classes by saying that it doesn't matter what we cover, but what we discover, maybe something that will challenge prevailing beliefs if we are fortunate."[7]

Furthermore, we as educators ought to encourage students to pursue their individual interests. Often this necessitates a dynamic teaching approach, requiring flexibility in material presented.

In my own personal experience, novel approaches in expressing content to diverse people can engage interest in the relevant disciplines. In my near twenty years of experience in tutoring, I've learned that synthesizing interests of the individual into explanations can facilitate learning; that is, a student is more likely to retain key information if she/he can relate said information to her/his interests.

2.3 Archivist

The third objective requires the educator to be a historian, an archivist of the relevant discipline's rich knowledge, and a keeper of quality control in scholarship. The historian attempts to accurately record knowledge for review by future generations. I've personally enjoyed collecting facts and information from a wide range of disciplines; in fact, I tend to think of myself as a permanent student, always learning, always growing. I greatly enjoy sharing this information with interested students and laypersons, either in the form of technical lectures or amusing anecdotes.

2.4 Architect

Finally, the fourth objective requires the educator to be a world-class architect of civilization, a mentor to the future architects of civilization, and a shaper of culture and technology. This is easily the most appealing feature of becoming

[5] http://unesco.org
[6] Freire, Paulo *The Pedagogy of the Oppressed*
[7] Chomsky, Noam. "Rationality/Science", *Z Papers Special Issue*, 1995.

an educator; I yearn to play a role in empowering many others to become leaders in the world, a necessary condition, in my opinion, for further democratization of civilization. Educational institutions play a large and measurable role in contouring the future, and I'm tantalized at the prospect of contributing to that role.

3 On Passion

3.1 The Role of Teaching in My Passion for the Abstract

I've greatly enjoyed pure mathematics since I was quite young; my research, puzzles, and even the vast array of "solved" problems often keep me up at night as I strive for deeper insights and a tighter grasp on connections throughout the complexity theory. I'm a problem solver, and both my discipline and teaching itself present quite difficult problems. Complexity theory captures nicely and formally a meta-mathematical model: how hard is it to accomplish a given task with fixed resources? Why is it that some tasks are impossible? Teaching challenges me further: how difficult is it to express a complicated idea to a relative newcomer? A rough answer to solving the less well-defined problem of strengthening my own understanding is in expressing these ideas clearly to others. As I mentioned earlier, I think of myself as a perpetual student, so I perceive my role in the classroom to be that of discussion leader; I ignite and direct the discussion, encourage participation, offer clarification, and bound the framework. As my students and I jointly explore the sometimes quite abstract concepts of theoretical computer science, my understanding often broadens alongside theirs complementarily.

3.2 The Role of the Abstract in My Passion for Teaching

In parallel to the development of my love of mathematics, I discovered from an early age that I greatly enjoyed giving lectures and expressing ideas to others. Some of my elementary school teachers gave me teacher's editions of textbooks at the end of the school year, hoping to encourage me to cultivate my interest in teaching. I often played teacher with my hapless siblings, giving to them assignments and grading their work. In my years as a tutor, a teaching assistant, and a teacher, I've discovered that the abstract realm of mathematics offers a superb challenge to one's capacity of expression. After all, mathematical abstraction simply is a difficult task, as supported by numerous studies through the years.[8] Thus, it follows that teaching this task to students is also difficult; I find the experience of explaining abstractions to students invigorating, as my technique must mature along with their understanding.

4 More on Teaching Objectives: Why Does Theoretical Computer Matter, Specifically?

Earlier, I remarked that expressing abstract concepts to students improves my own understanding of the discipline, yet perhaps more important is the benefit of cultivating theoretical computer science and mathematics skills for the students themselves. Learning to construct proofs and articulate correctness arguments contributes to the communication and logical toolboxes of students, I've discovered. I often insist on high quality standards in their technical writing, offering copious positive feedback and solution sketches to their submissions. Can students tightly construct an algorithm for a specific problem? Can they argue parsimoniously that a solution or proof is correct? These skills are (or rather ought to be) requisite for any position in a technical discipline. Again, I appeal to the inherent difficulty in formulating mathematical arguments: one might say that learning this skill is communication-complete (to borrow from the parlance of my field); if students can learn to express themselves clearly and concisely in the domain of mathematical abstraction, communication in more concrete domains should follow more easily.

5 Teaching Approaches

5.1 What Do I Do in the Classroom?

As suggested earlier, I conduct a dialogue during my lectures to help me measure the students' relative understanding of the concepts, to acquaint my students with one another to foster collaboration, and to help personalize the university

[8]Weber, K. *Student difficulty in constructing proofs: The need for strategic knowledge*, Educational Studies in Mathematics 10-2001, Volume 48, Issue 1, pp 101-119

experience. Not all students respond positively to my approach, but the general consensus in my evaluations suggest the majority find the dialogue useful. From time to time, I'll direct group activities, requiring cooperation among students and encouraging exploration. In keeping with my general objectives as an educator, I hope to nurture their interest in learning for its own sake, not just learning the specific material before them.

5.2 What Do I Do outside the Classroom?

I encourage students to attend office hours; I've found that they'll ask questions when in a smaller group that they'd not ask in class. In fact, benefits of smaller class and group sizes have become apparent over the last several years, showing a diminished income gap[9], improved student performance[10], and more intimate and effective working relationships.[11] If I'm unable to control class size, I feel that requiring small group meetings during office hours encourages class participation and improves student performance overall. My own experience corroborates the latter two; the first aligns with my core teaching objectives.

6 Assessment of Performance

I typically assess performance based upon improvement in style and correctness of proofs over the semester. As I mentioned earlier, I offer feedback, mostly positive to neutral in tone, to augment the students' interest in self-improvement. I find that encouragement tends to nurture learning better than negative criticism or paltry feedback. Further, I assume at point-of-entry that computer science undergraduates know very little of arguing mathematical formalisms, so I'm generally more interested in whether they can argue better by semester's end. Weighing heavily in their favor is genuine interest in the topics and whether they participate in class and office hours discussions. I prefer a student with low beginning performance who improves considerably and demonstrates a thirst for the material to an above average performer apathetic to the curriculum, or worse yet learning itself. Again, I hope to improve the communication and logic skills of the students by semester's end; I recognize that undergraduates (and even some graduate students) often need not remember specific details from a deeply theoretically-based curriculum but rather should cultivate the broader, more general skills needed for success outside the theory classroom.

7 Conclusion

In conclusion, my teaching philosophy closely follows tenets of the Age of Enlightenment. My hope is to not just convey specific material or attempt to fill empty vessels, but to instill in my students the same passion and love of learning that has guided me to mathematics, technology, education, and research. Core to any reasonable teaching philosophy is the objective to generate better citizens of the world; I feel that learning, growing, doing is essential in bettering oneself, and incumbent upon me as an educator is to engender and nurture these traits in my students. Therefore, being an educator offers me the opportunity to practice these tenets in the institutional setting, toward a better society and more prosperous civilization.

[9] Achilles, C.M., Finn, J.D., and Bain, H.P. (1997). *Using class size to reduce the equity gap.* Educational Leadership, 55(4), 40-43.
[10] Biddle, B. J. and Berliner, D. C. (2002) *Research synthesis: small class size and its effects*, Educational Leadership, 59(5), 1223.
[11] Zahorik, J., Halbach, A., Ehrle, K., and Molnar, A. (2003). *Teaching practices for smaller classes*, Educational Leadership, 61(1), 75-77.