Public Invention

Robert L. Read

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Public Invention, a US public charity

If you want to build a ship, don't drum up the men to gather wood, divide the work, and give orders. Instead, teach them to yearn for the vast and endless sea.

– Antoine de Saint-Exupéry

Preface

This is a draft work whose purpose is explain and promote Public Invention as a movement and philosophy. My hope is to create a coherent and convincing work. This work will likely be published electronically by Public Invention (the organization), but we will also seek a print-publisher who is willing to keep the work open access.

– Robert L. Read

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The Joy of Public Invention

1 "Invent in the public, for the Public."

Benjamin Franklin (1705-1790) did not patent the Franklin stove because he believed it to be too useful an invention to legally encumber. Benjamin Franklin has been called "The First American"[1], but I think of him as the first Public Inventor. If you read the autobiography of Nikola Tesla (1856-1943) "My Inventions"[2], you discover a devout public servant (in a non-denominational sense), who certainly wanted to make money but whose deepest motivation was to see human progress. R. Buckminster Fuller (1895-1983) wrote extensively on the act of invention as a moral act: nerve gas is bad, vaccines are good[3]. Richard Stallman (1953-) articulated the principles of free software and in so doing indirectly increased the wealth and well-being of the planet tremendsouly[4]. This book is my attempt to extend and promote the work of those inventors to create a stronger movement which we could call Public Invention.

Invention is the most spectacular way to advance human progress. It is odd that our politicians mostly ignore it. The story of human history is largely a story of technological advance careening foward from the stone age with a speed which is inexorably, and frightentingly, building, perhaps to a climax. Those who believe it will end in a dark and terrible destruction are not fools; but that fate is not certain. We as a planet can choose instead to build a bright future in which humanity explores the universe together in peace. This will happen only if we understand technology as the powerful moral force that it is.

For the last 100 years, technological advance has been driven by two engines: profit and academic research. The modern emphasis of Universities of patenting research and the governmental practice of subsidizing research which is monopolized by for-profit firms has blurred the distinction. Nations have long recognized the value of technology for competiting with other nations via war or mercantilism. Public Invention hopes to be a movement that does not replace for-profit research and academic research, but becomes a third engine. The motto of Public Invention is "Invent in the public, for the Public."

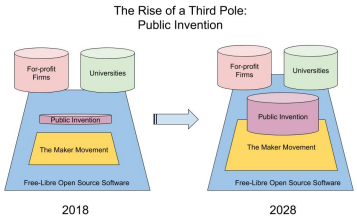

Figure 1.1: The Rise of Public Invention as a Third Pole of Progress

This means the Public Inventor does not seek monopolies in the form of patents or other intellectual property but gives an invention freely to the whole world without prejudice. Anyone is free to use the invention, including for the purpose of making a profit, but nobody is giving the privilege of exclusive rights to it.

Buckminster Fuller made a clear distinction between what he called "killingry", or weapons, and "livingry"–that which increase the good in the world. The Public Inventor must not build weapons. This is impossible to do perfectly. Even a pillow can be used as a weapon. Nonetheless, technologists are not relieved of the duty to invent good things instead of bad things just because it is intellectually difficult to decide what is good and what is bad. The Public Inventor accepts this burden as does the best they can.

Benjamin Franklin said, "We must, indeed, all hang together or, most assuredly, we shall all hang separately." His wit was poignant because

he meant the American revolutionary leaders would indeed have swung from a British rope for treason if the Revolutionary war had been lost. But in 2021 his words still ring true. Buckminster Fuller believed that humanity would either destroy itself or have a bright, Star Trek-like future—there is no middle ground. We cannot continue to muddle along taking weak action on global warming. The COVID-19 pandemic has shown that we are all connected in a most intimate way, whether we like it or not. A disease incubated in my body may kill you, and vice versa. Therefore the Public Inventor must at some level seek the wealth and well-being of the whole world. Narrow national chauvinism is no longer a useful or profitable behavior.

We could define Public Invention simply as invention in the public interest. In that sense, it is closely related to humanitarian engineering. Humantarian engineering requires a great deal of problem-solving, innovation, and ingenuity. The distinction is that "invention" means something truly novel which has never existed before. Public invention values the truly novel, whereas humanitarian engineering values the truly useful.

In the future, it will be common place for people to move freely between the three engines of for-profit firms, academic research, and public invention. Public invention will not replace the other two engines, but augment them. Public invention is a moral act, but it is not a moral duty. Some people will want to be public inventors some of the time.

The Joy of Public Invention | 2

Public invention takes the joy of invention and multiplies it by the joy of helping others. Making something truly new is a roller coaster ride of emotions. The inventor is frought with doubts. Is the invention even possible? Has someone done this earlier? Am I too stupid to accomplish this? Often a new idea creates innumerable frustrations. The expensive equipment breaks at a critical momemnt. There may be collaborators, but there are no experts to turn to, because by definition the invention has never been made before. Despite all of the doubts and frustrations, or perhaps because of them, the eventual progress, if it comes, is an intense joy.

Comic books and movies have taken a grain of truth and mythologized out of proportion to create the trope of the lone inventor. Most invention is done by teams. Math, is, in the end, always social. The joy of collaboration is part of the attraction of being a public inventor.

Each of us is unique and has unique gifts to bring to the table. In a sense this is true in any part of life, but it is a especially true in the act of invention. Each of us has a different voice, even if we sing the same song. However, by definition, invention is making something not just new in the sense of a variation of something old, however unique, but new in the sense of breaking new ground. An invention is not yet another rose, it is a new kind of flower. Even mediocre inventors such as myself are essential and necessary. The mediocre work makes the great work easier.

Some people have an invention inside them that has to get out. The seed of an idea planted in childhood may mature in the unconscious until the time is right for it emerge. Sometimes this is because of a persons great love of something. We have all seen people enchanting by flying or infatuated with light. Some people can spend years entranced by a math problem. The inventions may be useful, but unprofitable. Some may even be potentially harmful. Certainly many men, including myself, are fascinated by shooting things at high velocity, such as in guns or rockets or bows or catapults or water guns. So long as the invention is not designed to harm, the invention should be allowed to be born. The line between invention and art is sometimes blurred. The public inventor should support whimsical inventions when a person has a strong desire to make it.

The public inventor should not make fakes or toys. That is, the public inventor should make an object whose value is that it is a miniature version of some other object or like some other object which has intrinsic value. Making a model of a beautiful airplane or ship is valuable and fun, but it is not invention. Making a fake starship is not invention.

However, the desire to make something new even if the utility of the invention is hard to define should be respected. This may be because it is artful, or may have nothing to do with art, and its value may lie in some other dimension. Often, an invention that wants to be made that has no clear purpose is a forerunner of something else which cannot be conceived until the first invention is real and can be held in hand.

To me, public invention is really about love—love of humanity, of beauty, of the planet, of math, and of my fellow-inventors. For some of us, the joys of learning, collaboration, invention, and helping the world melded together in public invention is the greatest joy we can imagine. At the end of my life my proudest acheivement will be my children, and my second greatest sense of joy will come from the inventions I have given the world, however small they may be.

Why it makes more sense than in the past

3

Participation in public invention makes more sense with each passing decade. Although we suffer from inequity, in raw terms the world is more abundant than ever before. Commodities are cheaper. Fewer people live in poverty. The number of people who are financially able to take a few months out of the work force to work on a public invention project without compensation is higher than ever. People are more generous than ever before. The number of people who make a substantial income essentially through patronage and tipping is probably hire than ever before. In a world of abundance, the need to make a profit or to work relentlessly at a career should become less imperative.

In America today, housing in large cities and formal education are exceptions to the general trend of things becoming cheaper and easier to obtain. Participating in public invention is a powerful way to obtain two things provided by a formal education: the learning and reputation.

There are specific technical reasons certain kinds of public invention are far more accessible than ever before. In the first place, the internet has made many tutorials and how-to documents available almost for free, from how to use a soldering iron to very sophisticated academic papers. Secondly, the free software movement has made an ocean of high quality software available. Although it takes effort, almost any computing task can now be accomplished without paying a cent for software. It remains the case that some of the best scientific tools do not yet have free-gratis alternatives of similar quality, but the trend is incontrovertible: the cost of computing is getting cheaper. I'm writing and typesetting this book right now using mostly free software tools. This same software generally also makes it cheaper to build new software. Usually, software that it free as in free-pizza is free as in free-speech—meaning that anyone has the freedom to use it as a starting point for making something new. Software has limitations, but it is extraordinarily versatile. It is the most general-purpose of all technologies. The fact that it is free is a fundamental enabler of public invention, because capital attracted based on expectations of profits is not needed.

Hardware is more expensive, but has gotten dramatically more accessible at a low price. 3D printers that cost USD$300 can now do astounding things that were not even possible 30 years ago. Similarly, it is now possible to design printed circuit boards on free software and have them fabricated and very low costs, usually in about two weeks. This capability augments the old-fashioned but still useful soldering iron as a means of making sturdy circuits. Of course the reduction in the price of computers, which includes single-chip micro-contollers used in electronic embedded systems is legendary.

Although I am weak on bio-hacking, I believe the same expansion of capability at reasonable cost has occurred in the word of biology and biochemistry. Even optics, in the form of microscopy and teloscopy, has seen major improvements.

Batteris and solar power have enabled deployment of electronics portably and to remote off-the-grid locations. Significant improvements in cameras, sonar, and other sensors have also increased the sophistication available at low cost.

(Create Matrix/Infographic of relative acceleration in fields.)

Although hardware cost remain a relative imepdiment (see Chapter 22 for Public Invention's policy), the combination of cheap hardware, free software, and cheap connectivity has made innovation and invention much easier. Sharing and publication of inventions is a critical part of public invention, and that is also now easier than it has ever been.

4 Social Inventions

Advances in "hard" inventions have made public invention easier, but "soft" inventions also play a role. In particular, practices pioneered by the Free Software movement, such as the way projects can self-organize and use free software and hardware licenses, enable running a project and sharing it freely.

The free and open-source software has developed a set of cultural practices that allow teams to work together. These include:

- cultural dissuassion of unnecssary splitting or "forking" of a project,
- using recognition as an incentive for contributions,
- using version control systems to manage contribtuions,
- and using Agile software methods and big visible charts to manager work.

"The Apache Way"https://www.apache.org/theapacheway/ is a valuable starting point, as is "Homesteading the Noosphere"http://catb.org/~esr/writings/homesteading/homesteading/ and my own work, "How to be a Programmer" https://github.com/braydie/HowToBeAProgrammer

An additional practice is that documenters and maintainers are valued nearly as highly as software coders here. This is a cultural practice which is of paramount importance to public invention as a movement. Often, an invention has a kernel of math or ingenuity that can only be created by someone well-versed in the appropriate science and art. However, public invention is a team sport. Every contribution must be honored and valued. In some sports, some positions naturally have more opportunities for drama—the striker on a football team, the pitcher on a baseball team. But teamwork is essential to winning. Those who manage projects, write documentation, help with quality assurance and provide financing are equally important.

Eric S. Raymond has explained this in his essay "How to Become a Hacker" in in the "Status in the Hacker Culture" sectionhttp://www.catb.org/~esr/faqs/hacker-howto.html[6]

The value of these cultural inventions cannot be overestimated. But the creation of the GNU General Public License (GPL) is of equal importance. The GPL is brilliant in its simplicity: it gives the user the right to modify and distribute a copyrighted work and works derived from that a copyright work so long as the distributor does not attempt to monopolize the works and gives the derived work freely under the same terms. The GPL and related Creative Commons licenses give creators control over how their work is used. In particular, they may choose to enable re-use, which is the point of public invention.

The work of the Richard Stallman and the Free Software Foundation in the creation of the GPL has inspired many other licenses practically created the field and practice now called "free culture". This goes far beyond the GPL, but we can use the GPL as the originating event for these other licenses.

There are also reciprocal licenses for hardware. Hardware designs are not covered by copyright, and so they are fundamentally different. However, this is of no concern to the public inventor, who as a matter a principle is giving away the invention for the whole world to use freely. It would be nice of those who take a device and made improvements to it would contribute those improvements back to the project and the world as the GPL forces in software, but at present our legal structure for doing this is weak. We may, however, rely on the "honor system", which can be astoundingly effective in practice.

- Practices pioneered by the Free Software Movement
- Internet community
- Open Source Software paved the way with certain teachings
- Projects need leaders
- Projects run on the coin of acknowledgement

- Maintainers and documenters are highly valued
- Licensing matters, but has been pioneered

Imagining what it will be like | 5

- Infographic of the third pole
- Smooth flow into and out of for-profit business
- Profit becomes one of many tools
- Easy to find a project that resonates
- Easy to contribute something
- But invention will always be hard, or it is not invention.
- Replace vanity with gratitude
- Imagining an altruism driven project landscape
- Art and play in its place rising above infantilism
- How to Achieve a World of Public Invention
- An Ocean of Interesting, organized projects
- A community of sharing
- A means of getting of financial help
- A means of getting mentorship
- Judgement where it belongs

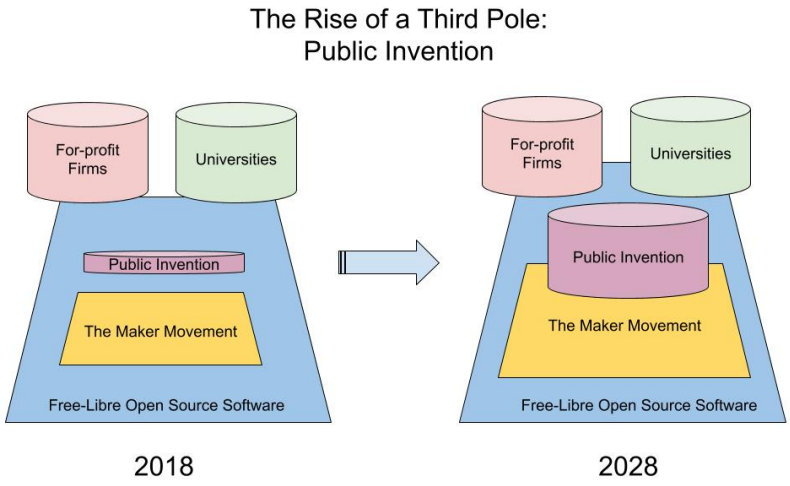

Figure 5.1: The Rise of Public Invention as a Third Pole of Progress

The Stoic Point of View | 6

- Basics of Stoicism
- Nature and Reason
- Stoic Communalism and Inclusivity
- Stoic views on occupation (Aurelius, Epictetus)
- Stoic assistance to the public Invention
- Resisting the siren songs of praise, the "in club"
- Resisting the siren song of excessive wealth

Find quote by C.S. Lewis on the "In club"

The Christian Point of View | 7

- Custodianship
- Jesus never touched a soldering iron, but a soldier's iron touched him.
- Love your neighbor as yourself. (Matthew 22:35-40) – the second half of the great commandment
- The first part of the great commandment implies that all science is theology. By studying his works we study God; there can be no love without knowledge.
- The second commandment requires sharing and egalitarianism.
- If we are called to be little Christs, and God cares for every sparrow, then we must as well.
- Talents must not be buried, and surely those of us who can be inventors have a talent: Matthew 25:14–30 Pauline comments: Whatever your hand finds to do, do with all your heart. (Ecclesiastes 9:10) Each has separate gifts: (Ephesians 4:11-16)
- We are made in God's image; and is not God a Maker and Inventor and Mathematician?
- Christ was not a carpenter, but a builder

8 Universal Salvation

- Small is Beautiful
- The road to the stars runs through villages and slums
- None of us are free until all of us are free
- Anthropomorphised money does not love poor people
- Nor does it love rich people.
- It wants to accumulate.
- But people love people–we can motivate volunteers this way
- We cannot live together on spaceship earth while we have grinding poverty
- Cutting your own carbon footprint in isolation is of limited value compared to political action—yet we are "sold" such ideas.

Building a Public Invention Commons

9

- The value of a Commons
- The value of Commons of Problems
- The value of a Commons of Solutions
- Don't worry, be crappy.

9.1 Public Invention as an Organization

This book is an attempt to create a movement called public invention. I have also created an public charity of the same name. Public invention, the movement, has always been and will always be more important than Public Invention the organization. Organizations come and go. You are free to create a different organization to support public invention, and I hope you do. Why then have such an organization at all, when it is clearly not strictly necessary?

Public Invention, Inc., is a US 501c3 tax-deductible public charity.

Hardware invention and non-theoretical science projects require more capital outlay for tools and consumable supplies than pure software and math projects. Once a project starts to spend a significant amount of money, it is useful to have a formal business organization. People who want to support a project want to know the money is not spent negligently. Being a non-profit registered by the IRS makes gifts tax-deductible for some givers in some circumstances, which may increase donations.

The basic practice of Public Invention (the organization) is to attempt to support the projects which we deem the most active and highest-priority by paying for material costs. We call this the "NOOPE" principle—No Out-Of-Pocket Expenses. For example, we will pay for printed circuit boards, 3D-printed parts, tools, experimental apparaturs, micrcocontrollers, breadboards, batteries, etc. We do not envision being able to actually pay public inventors for their time, with some rare exceptions, generally associated with producing "short runs" of devices in which we actual obtain a number of working devices. It has been our experience that engineers and inventors are highly motivated when people buy them equipment, even if the cost of that equipment is small compared to the salary they could likely obtain. This policy therefore has a high return on investment, measure in terms of impact, for every dollar donated.

Maintaining a list problems or projects worthy of effort is extremely valuable. Plenty of very valuble organization of entire fields is done by dilligent individuals.. However, some work requires input from several individuals, and this work must be judged and evaluated in some way which is best served by an organization. In particular, the attention of any one individual is limited in time. Some projects and work demand to be sustained across periods of time longer than a human lifetime. Organizations can such work better than individuals.

For example, "Ten Semi-Grand Challenges for Quantum Computing Theory" by Scott Aaronson TenSemi-GrandChallengesforQuantumComputingTheory

Similarly, an organization can sometimes serve an editorial function. Positively, an organization can embody conventional wisdom that evaluates the importance of certain problems. More negatively, an organization can serve as a badly needed quack-filter. There is always the danger, of

course, than an organization will engage in group-think, and repress valid ideas. Nonethelesss, an enormous amount of time and is wasted by frauds and crackpots.

Newcomers benefit from an obvious starting point. An established organization provides such a starting point, even if the newcomers later develop their own interests which take them away from the organization.

Of course there is always a danger that an organization will attempt to control or monopolize a project or even a problem space, or worse, a group of people. In such cases, creating an alternative or competing organization may be required.

Sadly, it may be necessary to have organizations which conduct business in different human languages or in different geographic regions. In a sense, it will be a great validation for public invention (the movement) when someone feels it is necessary to create an alternative to Public Invention (the organization).

How to Be a Public Inventor

How to be a Public Inventor | 10

- Motivate yourself through love of humanity, life, and knowledge
- Publish early and often
- Don't seek patents
- Publish your failures
- Seek community
- Help other Public Inventors
- Ask for Help
- Learn by doing
- Failure in service to a big idea plants the seeds of success.

Money and Volunteerism | 11

- Despite appearances, more of us have more time than ever before
- Gandalf "All we have to do is to decide what to do with our time."

The Emotional Intelligence of the Public Inventor

12

Invention means creating something that has never been created before. By definition, the Public Inventor is doing something difficult. True creation is a both a satisfying joy and one of the frustrating slog. By articulating some of the emotional difficulties they will likely face, we hope to prepare them.

12.1 Getting to the Coal Face

The first problem faced, even before any insecurities, is "getting to the coal face." This means specifically learning enough but a particular area to have some discernment on what constitutes a good and new idea. When I was a boy, I tried to think of a perpetual motion machine. I excuse myself because of my age; but only just. Although I didn't know it at the time, I had no right to be thinking about that problem because my entire knowledge of thermodynamics was the use of the word "entropy" in a Fantastic Four comic book. I was not at the coal face—I had not done the work, analogous to traipsing deep down into the mine to where the freshly exposed ore was—and so could hope to do no real work. A person who does not get to the coal face is either ignorant, as I was, or a quack, as I hope not to be. We must treat the ignorant gently, becuase often it is not easy to tell if you are ignorant or not.

This expression can also mean "doing the nitty-gritty", I do not mean it in that sense.

One of the easiest ways to tell if some one is a quack is to see if the have gotten to the coal face. That is, can they intelligently discuss the details of particular specialized area pertinent to their invention? If they cannot, their attitude will determine their fate: the merely ignorant will take the discovery that they do not know as a signal to study further, even if dejected by it. The quack will attempt to deny reality and become combative.

For the sake of the young especially, we must never say "No, you are wrong" without also saying "but it was a good try, and if you study this and that, something may come of it."

12.2 The Insecurity of New Ideas

For example, I recently discovered something of real if minor scientific value—or so it seemed to me https://github.com/PubInv/segmented-helixes/blob/master/doc/StackingHelix.pdf. This is quite unusual, and the more valuable something is, the less likely it is that we are the first to think of it or develop it. Extraordinary claims require extraordinary evidence (ECREE), the so-called Sagan Standard https://en.wikipedia.org/wiki/Sagan_standard, is fundamental to all scientific emprise. I of course did about ten hours of searching to attempt to verify that it had not appeared in writing before. However, even after working on it for six months and preparing the publication, I was riddled with doubt that this might simply be so well-known that

nobody bothered to write it up. In an attempt to allay my fears, I asked for help, and I think an anonymous person said it was not valuable and "pretty simple". Nonetheless, reputable journals continued to publish work which completely subsumed by my work. COVID-19 delayed the in-person conference where where the work was accepted. I remain in a state of emotional trepidation about this work, and unable to judge if it is quite signifianct or trivial. Many public inventors are going to be in precisely the same position.

We will be most effective if we can put aside our egos without decreasing our emotional involvement in the work. I care about the outcome of this research, in part because I simply love mathematics itself. I am not ashamed to say I love my work. If it turns out to be insignificant or previously published I will be disappointed. However, we must not allow such sentiments to cause us to be in anyway biased or discouraged. We must at all times hold forth the highest standards of honesty and academic integrity. It is our duty to publish results; in a sense, this is therefore self-promotion. But we must not over-sell or exaggerate our accomplishments.

12.3 The Dreaded Scoop

About twenty times in my career as a Computer Scientist and Public Inventor I have somehow informally presented an idea to someone or a group of people, only to hear them say, "That's been done." Sometimes they add some additional information about who and when, but often their memory is vague. To a would-be maker, inventor, or researcher, "That's been done" can feel like a punch to the solar plexus.

My advice is: Don't you believe it.

All of the twenty times I got that sinking free-fall feeling in response to "thatsbeendoneism", and I took notes and researched what I was told. Approximately once it turned out to really be true. The other 95% of the time, the work mentioned in no way decreased the value of the project I was undertaking, and even validated it. Sometimes it seemed to have no relation whatsoever. Sometimes it was tangentially related, but the previous researchers had taken a very different approach. Sometimes they had begun and stopped, and in the twenty intervening years the march of technology, and even mathematical theorems, has since opened up new vistas.

I don't like the way the word "privileged" has come to be used in the last 20 years, but in that usage of the word, as a researcher, I have been. I can be an over-confident ass, with the redeeming feature of complete blindness to my own ignorance. I am anti-fragile. Yet, I suffer from the impostor syndrome and insecurity, just like everyone else reading this, I suppose.

Judging by the emotions I personally go through when I hear "That's been done", I'm sure those words have prematurely killed many a fine and interesting research project, invention, or even DIY craft project. We must forgive the thatsbeendoners, and understand them. They are genuinely trying to inform us. However, the human weakness of a desire to appear

knowledgeable combines with the human frailty of not listening patiently enough to our ideas before passing judgment, multiplied by the human limitation of memory. The result is that most of the time when someone says "That's been done" you should carefully note what they say, plan to carefully research it tomorrow, and not worry too much.

Many research topics can go in about ten different directions. Any one researcher may have considered two of them; the other eight are open to you. When this is not true, you will likely know, because these become recognized under the moniker "open problems".

Do your homework and spend a lot of time in the library or researching online. When you have done that, work boldly and confidently in whatever direction your spirit guides you.

12.4 Publication

By definition, the public inventor publishes. This can take many forms, but the most challenging and most rewarding is academic peer-reviewed publication. Society has creating a beautiful machine, which we might call "the body of human knowldege", or, more colorfully, the exobrain. The internet and the trend toward open-access publishing has made this knowledge more accessible at lower cost and more widely shared than ever before. Google deserves a hat tip for their role in this, which has made "to google" an understandable verb.

Tony Stark, eat your heart out!

Long before their was the internet, it was systematically categorized and edited. In fact, we can think of the peer-review by qualified as reviewers as the best editorial function in terms of selecting what is worthy. Nothing stops you from publishing your work on the internet, but without peer review your potential readers must make a higher investment finding, evaluating and validating your work for themselves. In a sense, a paper worth 10 microfullers by itself is worth 20 microfullers when placed in a journal because of this editorial and validating function.

Academic publication lasts approximately forever. The exobrain is an gift that keeps on giving. If you could receive some sort of money or karmic value for your work, academic publication is the best way because it would keep paying you year after year as your work assists others. Sadly, this is not possible today, and the only people who derive economic benefit from academic publishing are the harried and beleagured class of assistant professors. In fact, because today you often have to pay open access fees, academic publishing is a slight economic detriment to the author. But it is a tremendous unrealizable economic benefit to your sibling scientists.

Publishing is, however, tedious for the public inventor. The quality bar for preparation is quite high. Finding an appropriate venue for publishing takes about half a day, and then there is a high margin for error, even after reading papers in many different venues. Finally, it takes months to receive a reply and often it appears the reviewers spent about twenty minutes reading the work and didn't seem to really understand it. Then, you may get rejected, and when you are not rejected, you often have

The decrease in the cost of paper publishing the low-end of the spectrum of publishable quality has been expanded, which I consider a good thing.

Professional academicians don't have this problem, but we cannot expect everyone to stay on top of all journals and conferences in a field.

additional work, sometimes substantive but usually just formatting to do.

Despite these troubles, I strongly encourage inventors to pursue academic publication for those works that deserve it. At Public Invention most of our project aim for a acdemic publication from the first day, but other projects are art projects or exploratory in natue. Having a posse—siblinghood of technical friends who can advise you—facilitates this decision.

12.5 Humility: Be Foolish

An invention project which is guaranteed of success is hardly worth the name. The public inventor must therefore be prepared to fail. Sometimes we learn the universe is harder to manage than we thought; this learning is valuable. Sometimes we learn that we have been foolish. This is an equally valuable lesson, though it can be a jagged little pill to swallow.

12.6 The Glory and the Impossibility of Comprehension

"Space is big. ... I mean, you may think it's a long way down the road to the chemist's, but that's just peanuts to space." – Douglas Adams, The Hitchhiker's Guide to the Galaxy

The Universe is "Infinite in All Dimensions."[**Dyson1989**]. When Freeman Dyson titled his book of essays that, he did not mean only in the spatial dimensions. It appears to be infinite as we look out and as we look in. It appears to be infinite as we look at the large and at the small. Human progress has created, or perhaps has been driven by, an ever expanding understanding of the richness of the creation we inhabit. Most recently, the discovery of thousands of known exoplanets implying a galaxy full of them, is a spectacular example.

There does not appear to be any end to new art forms, and the old art forms are made large by the creation of the new art forms. Photography has not hurt painting. Recorded music has not hurt music in general. Free versehas not hurt poetry.

It has decreased the breadth of musical mastery in the general population.

`https://quoteinvestigator.com/2021/05/24/poem-tennis/`During the question period afterward, someone asked: "Mr. Frost, do you ever write free verse?" and Frost gave his famous answer: "I would no more think of writing free verse than of playing tennis without a net." Vance spoke to the U.S. poet Carl Sandburg and presented his rejoinder: " ... I would have him know that I have not only played tennis without a net but have used the stars for tennis balls."

Amongst this embarassment of riches the public inventor may feel a little small. You can study all day for years and not master a single corner of the sciences, and most of us cannot make that investment in first place. I personally feel that I cannot master even differential equations and basic electronic circuits.

It is a personal shame of mine that I know almost nothing about chemistry.

However, we must support each other in our attempt to learn what we can in our brief time here together. It is not a question of knowing everything about anyting, but a question of what we should invest in learning. In this, the inventor has an advantage over the specialist: invention is often the combination of elements from disparate fields. The public inventor gets a pass on studying anyone one field, in exchange for a demand of voracious study of many fields. I personally could live no other way.

12.7 Feeling Unappreciated and Ignored

Somtimes the fruit of your labor sinks without a trace. Time and time again, great work has been ignored, only to be rediscovered, with great praise and thanks, thirty years later or more, when the original author is dead or has been denied tenure! And those are the lucky ones.

Sometimes an idea is ahead of its time. However, it is also entirely possible to do excellent work, and simply receive blank stares and yawns and in fact the work may never mean anything to anybody. This happens to artists fairly commonly. The only remedy when this happens is to do some other excellent work.

Working hard on a project for a long time that is completely ignored almost always positions you better to do some other project. I suppose it must happen that this is not always true, but it has never happend to me.

12.8 Patent Envy

There is a mystique around patents. The word "patent" is sometimes pronounced with certain breathless excitement, as if it confers success, riches, or some proof of merit. Don't be fooled—it gives none of these things, and costs money and time. About the best thing I can say about the patent system is that provides an extremely well-organized and useful database of clearly explained ideas. This is still used for, but was more useful when paper publication was the only route. However, it should have no mystique. By making an invention sufficiently narrow, it is possible to get a patent in almost any field. This does not mean it has any value to anyone.

A patent provides a monopoly for 20 years on some idea. This is antithetical to the entire premise of public invention. It made more sense when publishing ideas was harder. The long monopoly did not seem so long when the patent system was established in 1790.

All of humanity is in peril of extinction if each one of us does not dare, now and henceforth, always to tell only the truth, and all the truth, and to do so promptly — right now. — Buckminster Fuller.

Patents do occasionally prevent large firms from using the work of individual inventors without compensation, which is a positive feature. However, more often they are collected by large firms who finance their issuance from flimsy actual innovations and then use them to compete with other large firms and to create barriers to entry to the market for small firms. It is an idea that was useful in its time and in its form, that utility is now passed, and the patent systems needs to be reformed.

There are people who will passionately argue that without the monopoly provided by patents nobody would research new drugs, for example, or other useful inventions. There has been plenty of great research in software and mathematics which luckily was only slighlty tainted by patents. Being the first mover in a market with an invention provides a tremendous financial incentive. If those prove insufficient, society could finance pharmaceutical research through taxation or even donations. However, public policy should not influence what the public inventor does.

The question is: will an invention serve the public better by being patented? The answer is usually no.

Patents give the inventor the right to file for one year after a public disclosure. Furthermore, by law, all inventors must be named in the patent. Both of these stipulatons are nearly impossible to accomplish in the modern, open-source way of working. The modern way to develop is to work "in the light", not keeping one's work secret. Since public invention invites broad participation on projects, there are often dozens of volunteers that work on a project, and sorting out who contributed what is a thorny nightmare.

Whatever one may think about patents, they have no place in public invention as a movement.

12.9 The Need for and Difficulty of Fellowshp

There is no more secure entry to friendship than a shared passion. The public inventor often wants friends, and wants to share their passion. Often, even when working in the light, this need is hard to satisfy.

A detractor could argue I am writing this book to have a lot of virtual friends.

In an all-volunteer project in which nobody gets paid, volunteers are ephemeral. They may come and go. Sometimes they are seeking to learn but are not really ready to contribute, and cannot really be a peer. In some circumstances, people are simply jerks.

12.10 The Darkside: Going Closed Source

During the great pandemic ventilator rush of 2020, there were several teams that made high-quality open-source ventilators and respiration tools and then chose to continue developement in a closed manner, probably because they enterred contracts with manufacturers who either pressured them to do so or took over development and were unwilling to continue in an open source manner.

I personally suspect many of these contracts ended up being "catch and kill" operations; that is, the teams got only a piece of future profits, and the firm had no incentive to make the devices. Thus the "killed" the project, and removed a potential competitor, and nobody was helped at all. This may have occured unintentionally.

Because the open source licensed for hardware are more delicate than the GPL for software, going closed-source in these cases may not have violated the law, but certainly violated the spirit of the projects when they said they were open-source. It also violated the expectations of most of the people (myself being one of them) who supported those projects with money, equipment, and time.

To bring inventions into practice, we need for-profit firms. The natural life-cycle of a public invention is to mature into something that can make a lot of money for someone who takes on the effort and risk of manufacturing and distributing it. Profit is good; monopoly is bad. It is essential to public invention that enormous amounts of money be made

from public inventions, and in general only a small fraction of that money, if any at all, will go do the inventors. However, the key is to keep the invention free and open so that it may be improved and constructed by anyone, including firms which are competing with each other.

If a firm comes to you and says "We will make this invention, but only if you make the project close-source so that we may have a monopoly", you should say, "No, that is not in the spirit of public invention. However, you are welcome to exercise the rights already given you by the licenses we have used to publish our work."

A copylefted work may be continued as a close-source work only by the copyright holders. Since a public invention team may be diverse, this may be problematic. However, if all copyright holders agree to continue the work in a closed-source manner, they may do so and the previously published work remains a free and open project. However, the world will benefit more if the work continue "in the light", and that is more in the spirit of public invention.

When a work goes closed-source, it tends to become invisible. This deprives the community of not only the work itself, but even knowledge of if the work is progressing.

"Very hard to see, the dark side is."

- Getting to the Coal Face X
- What to do when you are scooped X
- Dealing with publication X
  - Rejection
  - Timeliness
- Surviving being foolish X
- Investing in learning without pedantry X
- Feeling unappreciated and ignored X
- Fuller's theory of technological maturity and ripeness
- The need for friendship and siblinghood
- The siren-song of closed intellectual property
- Patent envy and the patent mystique X
- Dealing with disappointing teammates X
- The insecurity of insignificance
- Competition is obsolete
- St. Exupery's comfort of mediocrity - 20 bad sculptors are needed
- "A walk-on part in a war or a lead role in a cage"
- Paul's call for each to do their part: Ephesians 4:11-16
- Small is beautiful
  - Giants are built from small accomplishments, as long as they are published.
  - Thinking small is often a useful constraint.
  - Nothing does big things as well as doing small things.

A Publishing Disconnect between the Free Software Movement and Open Science

13

13.1 The Problem is Terminology

Academic researchers and the Free Software Movement (FSM) use the word publish differently. The difference in meaning in the word publish (and publication) creates a disconnect when the Free Software and Academic communities try to collaborate or when Academy adopts the ethos inspired by the Free Movement and the Creative Commons community, as we learned at a recent hackathon on behalf of Project Drawdown. Publication: Free Software Publication means putting anything, no matter how trivial or unrefined, online and potentially accessible to world, expecting it to be revised periodically and possibly linked to by others. Academic Publication means putting a work in academic journal after it has been critically reviewed and circulated for review by peers and trusted advisors, where it will be eternally unchanged, and possibly referenced by others. Free Software culture expects that works are "published = made accessible and known to a limited audience" from day one. Academic researchers often expect that things are not "published = announced in a peer-reviewed forum" until they have been thoroughly vetted and refined. This difference in expectations can challenge free software developers and academics who work together on projects. Nonetheless, such collaboration is extraordinarily useful and becomes more so every day. Creating a productive working relationship means creating a common understanding about expectations, the language used to describe the process, and the process of implementing the project. This essay is an attempt to explain this to facilitate these communities working together.

13.2 The Mutability of Published Works and Expected Quality

Expectations in the FSM are that works are eternally mutable: they are constantly improved and are never in a final state. In a free software project, the contributors may not know who will make the next improvement, since in theory a wide audience is invited to contribute. Contributors are recognized rather discreetly, sometimes not even by name, in the commit logs and spread out in comments throughout the code. Contributors to a free software project are not individually responsible for its overall quality. In academia the expectation is that a definite list of authors will take responsibility and great care for moving the work from conception to final, published state, after which it should not need any serious revision. Academia demands non-repudiation: each author is expected to stand behind the conclusions of the work with their reputation. Free software is "published" immediately. By published, free software authors mean it is available for anyone who cares to discover, to examine, comment upon, and and even build a rival to. There is no expectation that the work is highly usable, let alone finalized. Everyone accepts that some bugs will exist. In fact, the expectation is that you will make it available before

having a confidence it is bug free! Functionality often is achieved before all of the possible ideas the original author have come to fruition. The ethos of "release early and release often" embeds this idea. Well after first publication a project will reach the first point of functionality. At that point free software authors will frequently make a "release." The "release" of an open source software project is symbolic; it is an assertion of readiness rather than a revelation of information. Once a "final" release has been published it is a indication that the authors believe it has some degree of usability. To working programmers, the release is a non-event; the development process immediately continues to revise the code base to add more functionality and fix any bugs, which are expected to be discovered in the previous release.

13.3 Quality Standards

Academic publication (and traditional writing at large) has a different standard to meet for publication, which is a momentous event. The work product is the explanation of an idea. Authors are judged and criticized on how accurate or complete the idea is. Significant flaws in the idea or its explanation are problems indicating that publication and sharing the idea was premature. Publication is a seal indicating a level of quality and finality. Not only does free software not have this sense of finality but the standard for quality, minimal functionality, is entirely different. Typically in academic publication there is no similar standard to being functional. English prose can only express an idea; to the extent it is a "useful" idea (as opposed to just an abstract idea) it requires someone to apply it through more work. Free software has the advantage of doing work in its current state, typically without the user even understanding the ideas expressed.

Free software developers often expect works to be accessible to anyone or "Open from day one", even before anything useful is done. To them published does not mean publicized. The expected audience of a nascent project is tiny. Nonetheless, developers expect the underlying ideas, goals and data involved to also be shared publicly. They will expect every mistake and half-way step will be made freely available to any party that cares to go looking. They will not be concerned that mistakes will reflect poorly on them early in the process and expect to be judged on the progress and the process initially and only on the quality of work when the developer specifically states they believe it is high quality. Software is never "done".

In contrast academics have the expectation that works are only shared broadly with others when they have reached a final "done" or permanent state. The final, permanent state requires that the first publication be of high, even meticulous, quality and free of all serious flaws. The finality of the state turns the work into an artifact that allows others to judge and critique it as soon as it is published. Any reputational impact rests on the state of the work at the moment of first publication. Academic publishers seek to be respectful of their readers' time by producing the highest-quality work possible.

Free software developers have the advantage of being able to layer the fixes over there bugs that get buried in the revision control history. Academics mistakes are hard to correct silently once an article has been published.

13.4 Rivalry

In some cases there is a race to reach this final point of publication since reputational interests are disproportionately granted to those who publish first. Those who follow cite previous works, increasing the reputation of the previous works. In academia, sharing too much too soon might enable someone else to craft a publication that preempts the work and the reputational rewards that it carries. Authors of an academic paper circulate select drafts of the paper before publication to only a few individuals the author trusts. The author hopes that any criticism will be in private and that the carefully selected reader won't attempt to compete or usurp the opportunity to be the first to publish by rushing to the presses.

FSM developers expect that anyone could look at the work in progress and criticize, contribute to, or be inspired to create a rival to, the work. These activities have largely been embraced by the free software community and turned into opportunities to accelerate the progress of the body of free software generally. Rival works are common and to some extent validate the value of the work they seek to supplant. It is impossible to count the number of competing GNU/Linux distributions, LLVM has long been competing to supplant GCC as the default compiler in the free software world. These rivals encourage diverse approaches until one dominant modality emerges, which can only rest on its laurels for so long. As an example, in the important field of version control systems, RCS was replaced by CVS, which was largely supplanted by SVN, which lost to a competitive field of distributed source code control systems, until git as emerged as the dominant player.

13.5 Method of Reuse

Despite the different understandings around the meaning of "publish" and the expectations that come with the act of publishing, there are many similarities between writing an academic paper and developing free software. Both recognize the need to build on the works of others. Academic papers do this through a rigorous method of citation. Free Software does this by incorporating libraries written by previous authors into the work, or by modifying existing software directly. Both methods of production also recognize the need to circulate works prior to their general release to communities of knowledgeable individuals that can offer critical feedback to give a diversity of thought on the quality of work done so far and identify further work.

When a research paper cites a previous work it acknowledges the priority of the earlier work. Academics acknowledge the contributions of those who have expressed ideas previously:

- to give credit to those who thought of it first,
- to show that they are contributing something new beyond what has been expressed previously, and
- to give the reader a pointer to valuable reading on related ideas.

There are, however, no legal restrictions on the use of the idea in an academic paper, the citation process is not directly regulated by law, but rather by industry standards which carry consequences.

For instance, suppose you write a paper criticizing another person's paper for a logical flaw: you need to cite the flawed work to give readers a reference point. But if your reference point was not fixed in time and after reading your paper the author of the original paper repaired the logical flaw, your criticism no longer makes sense in reference to the now corrected paper. The change to the underlying paper being criticized robs those who criticize it of the reputational reward undermining the motivation to interact and collaborate to move the ideas and the field forward.

In contrast, Free software references code which changes frequently. By using some software, you are providing a small reputational reward to the author, not for having any particular idea fixed in time, but for having working code. When you borrow the implemented code you have a social requirement of acknowledgement. Typically it is even a legal duty, since you are literally textually copying copyrighted software into your work.

Software languages have been designed to make a weaker form of reuse by reference possible by the use of "libraries", which facilitate the use of software created by other authors. Often the expectation is that you will only reference the functional work rather than textually including the work, because there is a recognition that the softwares functionality will change and you want to be able to easily take advantage of the improvements. If someone fixes the flaw in the software you are incorporating into your software, your software doesn't typically stop working — just the opposite — the hope would be that your software now works better because it benefits from the fix as well.

13.6 Conclusion: How to Cooperate

Free software developers and researchers typically have different professional reward systems and expectations around mutability, rivalry, and means of reuse of their work, but this does not imply they are at cross purposes on a particular project. The key is to create a shared understanding and language to be able to precisely discuss the goals of the individuals and the goal of the overall project. The natural language of these groups diverges most around the terminology of publication. We present the examples below as a guide to clarifying this confusion.

FSM developers should be ready to say:

> "... publish the software..." ... by which we mean... "... place it in a publicly accessible repository without publicizing it."
> "... release the software..." ... by which we mean... "... make

a minor release which will only be noticed by dedicated parties."
"... make a major release..." ... by which we mean... "... we will make a public announcement which, while largely symbolic, will attract a lot of attention."
"... make this freely available..." ... by which we mean...
"... make it accessible with documentation and a license that it allows it be vetted, shared and improved, but does not carry with it any expectation that it is perfect, free or error, or even works very well."

Academic researchers need to be prepared to say:

"... data not ready to be published..." ... by which we mean... "... we don't mind people looking at the data, but we don't want to publicize it yet."
"... algorithm and model is not ready to be published..." ... by which we mean... "... we don't mind it being in a public repository under a public license as long as documentation and version control clearly reflect that we are still working on this and track our changes."
"... of course we invite people to improve this work, but we have not published it yet..." ... by which we mean...
"... we want it to be made accessible under a license but with an understanding that using this without giving us academic credit should be considered plagiarism."

Math and Programming 14

- The magic power of the inventor
- A little goes a long way, and there is never enough
- Mathematical inventions count
- The touchstone of truth - “Do the math”

15 Self-disciplines

- Study everyday
- Write everything
- The middle road: you are neither particular important and infinitely valuable
- Love matters more than lasers

What if you cannot be a Public Inventor? 16

- Give moral support.
- Give money in a way which is spiritually meaningful to you.
  - A small amount given to a small project is incredibly impactful.
  - People aren't compensated, but paying for equipment has a multiplier effect
  - It is psychologically important.
- Try to put yourself in a position that you can
  - Educate yourself.
  - Become financially sound—remove the desire for luxury

16.1 How to Start a Public Invention and Humanitarian Engineering Club at your University

One of the most impactful things you can do is to start a Public Invention and Humanitarian Engineering (PIHE) club at your University. (We recommend that PIHE be pronounced "PIE-hee"). Although one could of course start a club devoted solely to public invention, by including humanitarian engineering the appeal is broadened.

Humanitarian Engineering, [is the] the application of engineering to improving the well-being of marginalized people and disadvantaged communities, usually in the developing world.[7]

Humanitarian Engineering

Humanitarian engineering was first offered as a minor by the Colorado School of Mines in 2003. Organizations like Engineers Without Borders (EWB-USA) have made it a nationwide activity with over 300 chapters (see map below, or click here). The blue dots are EWB chapters, many of which are student chapters associated with Universities, and the red dots are community projects within the USA. EWB-USA focuses heavily on civil engineering (e.g. clean drinking water projects) in low and middle income countries. The COVID-19 pandemic, however, has made both the need for and abilities of humanitarian engineering clearer. Helpful is one of several volunteer organizations created in response to COVID-19 dedicated to humanitarian engineering. Humanitarian engineering has leveraged advances in digital manufacturing and open source sharing of designs to aid the world by creating personal protective equipment (PPE) and even sophisticated medical devices like ventilators. There is a need for humanitarian engineers in every kind of engineering discipline.

Starting a PIHE Club

Public Invention and Humanitarian Engineering are both movements that seek to use human ingenuity to help society and the planet. There are always highly motivated students interested not only in learning and increasing their earning power, but also by a desire to help their fellow beings and move society towards a sustainable state. These students

deserve a place to congregate, socialize, learn and teach together. The project-based nature of Public Invention and Humanitarian Engineering movements are a great way for students to be mentored and gain practical experience to augment their studies. We think every University should have a Public Invention and Humanitarian Engineering club.

At most schools, the students have the power to start a club simply by asking to do so, sometimes by filling out some paperwork to assure the safety of the students and that the club accords with the principles of the school. The university usually lets the club meet in a classroom or other room, and sometimes provides a small amount of money for things like pizza.

A student-formed organization may require a faculty advisor, and sometimes a minimum number of students to serve as the initial officers of the club. Usually, a statement of the purpose of the club will be required. We recommend that you use some variant of this purpose:

> The purpose of the [your university name] Public Invention and Helpful Engineering club is to explore and support the use of technology for the betterment of humanity and the planet, particularly how technology can address problems not being addressed by the private sector.

You do not need the permission of anyone outside your school to start a PIHE club, and your club doesn't have to follow any dictates that it does not itself choose. Every club can be independent. You are encouraged, however, to inform us at Public Invention (email: <read.robert@pubinv.org>) so we can give you a shout out as well as connect you to other club directors and presidents. We will help you find speakers and mentors as well.

Here is the preamble drafted at the University of Texas at Austin club:

> The local Austin Public Invention and Helpful Engineering Chapter is intended to support student awareness and participation in humanitarian engineering projects and free, open-source inventions with the public interest in mind.

What a PIHE Club Should Do

Whenever two or three people are gathered together, a spirit arises which is greater than the individuals. A PIHE club doesn't have to do anything beyond talk about the ideas of Public Invention and Humanitarian Engineering. But a PIHE club could also:

- Invite speakers to talk specifically about PIHE concepts, practices, and projects. Public Invention will be happy to come speak at your club!
- Take on real projects that can really make a difference. The organization Public Invention has published a growing curated list of such projects analyzed for difficulty, joinability, and skills that you can use as a starting point.
- Interact with a local Engineers Without Borders professional or student chapter, or consider starting one!

- If not ready to do a real research project, take on a learning project to improve your PIHE skills, such as building an open-source device useful for humanitarian purposes.
- Brainstorm new public invention ideas, and contribute those ideas back to the public invention list of ideas.
- Invite discussion of the philosophical, religious and ethical aspects of PIHE.
- Seek out ways engineering and technology can help in your local community, such as:
  - Mapping invasive species,
  - Providing sanitation to the homeless,
  - Recycling plastic with recyclebots into 3-D printing filament,
  - Measuring and decreasing the local carbon footprint, etc.

Of course, you can probably think of a dozen other useful and fun things! EWB student chapters have a very well-defined way to make a big impact by working with local low-resource communities internationally, but a PIHE club does not have to be structured that way. Your PIHE club will not be a chapter of a larger organization, so you are free to focus wherever you like. Some clubs may wish to focus on real-world project-based learning. Other clubs may want to chat about how an engineering career can be part of PIHE. Some clubs may focus on the environment, others may focus on poverty and inequity. What they all share in common is that they share their inventions and development to the commons!

What the Students Should Get Out of a PIHE Club

Although every club may be different, the students of a PIHE club should obtain certain benefits:

- The joy of sharing a common interest with your fellow students.
- The satisfaction of helping others, even if that help is abstract and potential, existing in the future rather than today.
- Learning how technology can positively affect the real world.
- Understanding the open-source and free culture movements.
- An introduction to modern project management tools such git`https://git-scm.com/`, GitHub`https://github.com/` and GitLab`https://gitlab.com/`, and Appropedia`https://www.appropedia.org/Welcome_to_Appropedia`.

If a PIHE club is ambitious enough to undertake its own humanitarian invention project, perhaps with the help of a professor or Public Invention, then students can expect mentors, real-world experience, practical motivation of their studies, and a great project to talk about in a job interview or when applying to graduate school.

Public Invention in the 2020s

Public Invention 201: Essential Skills

17

18 The Technological Landscape

I parts of this book will be read in the year 2100, but this chapter will be obsolete.

Selected Invention Ideas 19

"The world is full of interesting problems to solve." – Eric S. Raymond

How Public Invention Operates

The Invention Team Model 20

21 Sharing Immediately and Broadly

The Public Invention Licensing Policy

22

Why Public Invention is the best teacher, but is not an educational organization

23

- People learn best by doing.
- We don't do exercises, fakes, or toys
- Learning has an enormous social component
- Learning is a precessional outcome of Public Invention activity

Supporting Material Costs 24

25 You Can Help

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