Tinkering -
A vehicle for teaching innovation in the University Industrial Design studio

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Introduction:

Our Industrial Design program is young, barely twelve years old. The task given to us some ten years ago when my colleagues and I were hired by our university was to develop a vibrant program that would graduate students capable of successfully contributing to the design profession. This was quite a challenge considering where we were ten years ago. By some stroke of luck our ID program had just been NASAD accredited but regarding preparing our students for the rapidly changing design profession we had a long way to go. Having been hired during the program’s infancy has had its advantages and disadvantages. On one hand as a program we were severely lacking in areas that were critical to our student's professional success but on the other there was very little that was established thereby giving us the freedom and flexibility to experiment with our own pedagogical approaches. We did not have to follow those that came before us or cater to industries that in one form or another were subsidizing our program. We were given the freedom that was necessary to experiment with new teaching approaches.

The inherent dilemma regarding the teaching of innovation is that if we become too prescriptive, or recipe oriented with our assignments and lectures we run the risk of missing the very essence of innovative thinking. How do we teach a subject that really can't be taught in the same formal manner that a language or science subject is taught? The answer lies in the teacher's ability to not be too restrictive and to create an environment that is conducive to creative or innovative thinking. What is this environment and what kind of tools and activities help students tap into the part of their brain that allows for innovation?

Our ID program is under the umbrella of the School of Architecture and Design. In fact it was our Architecture program that gave birth to Industrial Design at our University. As can be expected the Industrial Design program very soon after it's birth needed to establish itself as a separate discipline. The Industrial Design teachers took on the controversial task of clarifying what these differences were and where there were commonalities. One area that we felt we had in common with the Architects was their emphasis on a kinesthetic learning. All three disciplines within the School of Architecture and Design have their students take two semesters of a common foundations course where there is a heavy emphasis on a hands-on model building. In Industrial Design we continue this hands-on approach through our program till they graduate. We feel that many important discoveries are made during the activity of “making” and when we are working three dimensionally with materials. There is something about having one’s hands on the materials that stimulates original and personal insights.

One of the experiences that we hear students enthusiastically talk about as budding designers is the "happy accident". They might talk of the discovery of some new property of a material that they hadn't noticed before and that it was when they were intending to resolve another problem that they noticed something about a particular material that they hadn't noticed before. Often where there occurs intentional, experimental manipulation of materials for some anticipated outcome, there results new unanticipated discovery. This intentional, experimental manipulation of materials is referred to in this paper as “tinkering”. It has become my ambition as a teacher to encourage the occurrence of the "happy accident" by encouraging whenever possible the tinkering activity.
Hands-on model making and tinkering

Let us first address how this paper refers to “tinkering”. The term tinkering has had some negative connotations. Often it has implied useless unskilled activity, as in: “Stop tinkering with that clock and bring it to a repair shop!”. In this paper the term “tinkering” is used differently. It describes a hands-on, often problem solving, kinesthetic, and experimental experience. Rather then a useless unskilled activity the definition for this paper might read : "To manipulate experimentally for a purpose."

In order to tinker effectively the activity needs a purpose. The tinkerer needs to be asking questions. The questions can have a wide range of inquiry from the poetic to the pragmatic. The question of how a particular shape makes a person feel is very different from how to make a contraption that makes use of mechanical advantage when lifting a heavy load. Both are questions that can be asked to inspire good "tinkering" activity.

The Perfect Tinkering Storm

In recent years it has become clear that tinkering is not only a wonderful teaching tool to foster innovation but it is historically extremely relevant. It is as if we have, historically speaking, the perfect tinkering storm. Before we talk about Tinkering inside the University ID studio, let us put the tinkering activity into a historic context.

• We are living in a very interesting time regarding design and innovation. The rapid change that we are undergoing couldn't have been imagined when the author was a child. When ever there is rapid change there are more problems to be solved and therefore more opportunities for designers. Just based on this argument it is easy to tell my students that it is a great time to be a designer.  Inventor and visionary Ray Kurzwiel on TED (Technology Entertainment and Design) made some interesting predictions. He was talking about a topic that he has been studying for the last thirty years; "tracking the advance of technology." He has 10 people working for him gathering data on key measures of technology in many different areas. From this data he built models that predict our technological future. In summarizing his findings Kurzwiel had this to say:

"My main message is that progress in technology is exponential, not linear. Many -- even scientists -- assume a linear model, so they'll say, "Oh, it'll be hundreds of years before we have self-replicating nano-technology assembly or artificial intelligence." If you really look at the power of exponential growth, you'll see that these things are pretty soon at hand. And information technology is increasingly encompassing all of our lives, from our music to our manufacturing to our biology to our energy to materials. We'll be able to manufacture almost anything we need in the 2020s, from information, in very inexpensive raw materials, using nano-technology. These are very powerful technologies. They both empower our promise and our peril. So we have to have the will to apply them to the right problems."

Figure 1 - Exponential technological growth
The question can be asked "why do human beings make things?" The conventional explanation is that it is out of necessity - hence the phrase "necessity is the mother of invention." Many historians have raised doubts that this is the sole reason. George Basalla, a well-known historian of technology, shows evidence in his book *The Evolution of Technology* that it is far more complicated than this. He has a section in his book entitled "Fantasy, Play and Technology" that describes the inventor not as "man the maker - homo faber" but instead as "man the player-homo ludens". He talks of illustrated technological extrapolations dating from the Renaissance that were never meant to actually be constructed. They were rather celebrations of technological possibilities of the time rather than inventions created out of necessity. Basalla also looks at the US patent industry and makes the point that most patents are never commercialized but remain unused in the files of the patent office. The point here is that humans don't always have a reason to make and invent; they just naturally do it. One explanation could be that our species has been making and inventing for a long time possibly 2.5 million years. It is likely that over the millennia we have developed a genetic propensity for invention that is linked closely to our survival.

Figure 2 – Seventeenth-century perpetual-motion machine. 

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2. Image of perpetual-motion machine from the 17th century.
Due to the current economic down turn there are a lot of jobless technologists looking for a place to funnel their creative energies. In the bay area alone there are over 100,000. This brings me to another interesting development. Groups of like-minded tech enthusiasts all over the world have been renting space, leasing or buying reasonably priced CNC equipment making it possible for individuals to exchange information and create that previously would not have been possible. These spaces located all over the world are called “Hacker Spaces”.

Figure 3 – Noisebridge, a collectively operated hacker space in San Francisco

Historically the garage or backyard inventor has had more influence on our technological development then he or she has been given credit for. No doubt, without cooperate research and development we would not have been able to put a man on the moon and many other amazing feats, but probably if we were able to unravel the history of influences on technological development the same could be said for the garage inventor. We have after all a multitude of heroic garage inventions like the apple computer that has been profoundly influential. There is an interesting book on the subject called Makers: All kinds of people making amazing things in garages, basements and backyards by Bob Parks, that compiles the influence of independent garage inventors.

Access to high tech CNC rapid prototype equipment has become exponentially less costly and the availability of electronic computer chips like the 8-bit microcontroller is no longer limited to the big electronics manufactures. Some ten years ago our school bought a CNC router for $42,000. One can currently buy the same machine for $4,800. Microchip developed an inexpensive compiler software that would let anyone program in the familiar language, C. Every year advances in technology give designers and technologists new opportunities to inventors with meager means. Inventors no longer have to be part of a large cooperate R & D team to make a contribution.
Information by accessing the internet has leveled the playing field. Today it is possible to be an innovator regardless of location as long as there is computer access to the World Wide Web. It is interesting to think about the history of our urban environments ie. how cities developed and grew near ocean ports and rivers. In the past working in the design field pretty much meant one had to locate oneself in the proximity of a city. Now with accessibility to the Internet, this is no longer the case. The ability to influence and be influenced by forces that are connected to the design world is at everyone’s fingertips, regardless of location, as long as there is a connection to the Internet.

We have all heard the term "skill-sets" in reference to preparing design student for the professional world. A skill set is a group of skills that when mastered will lead to a student's proficiency in a particular area. An example might be the drawing skill-set which can of course be divided into smaller sub skill-sets like rendering or ideation drawing. If you were to check out a comprehensive list of necessary "skill-sets" that are considered requirements for the professional designer you would be amazed to find that tinkering or any other reference to this creative activity is rarely mentioned. When we Goggle free lance Industrial Designers and look at what "skill-sets" they are claiming they are proficient in to market themselves we will find that innovation itself is rarely referenced. This is partly because "tinkering" is not thought of as a technical skill that can be taught. This is where the author differs. Tinkering can be taught but not in the direct and linear way as a subject like math or English. Instead of lesson plans it is better to think in terms of creating an environment that is conducive to the tinkering activity. Just like any other skill-set some students are better then others at it. Some come into the program with the ability either because they were exposed to tinkering as they were growing up or else they have a natural inclination towards it. This would be similar to a skill-set like drawing where some students have the natural ability or have been encouraged as children where others are just beginning.
Encouraging the tinkering activity in our design studios

So how do we as teachers of design create an environment that encourages the activity of 'tinkering'? These are my suggestions:

1. Encourage a Hands-on kinesthetic approach or physical exploration. Our students are encouraged to explain their concepts through model building or hands on discovery. At the beginning of a project it is good for them to run through many ideas quickly as opposed to fine-tuning and perfecting one model. We refer to these models as “quick and dirty”. They may be gestural in nature or they may be made for the purpose of understanding some other aspect of the project. Students often ask me; "What kind of model should I be constructing?" A design model should be constructed for the purpose of attaining information. The type of model that the designer picks should be directly related to the type of questions he or she is asking about the project. The question becomes: What is it that you, as a designer, want to know about your project? Once that question is answered the type of model becomes obvious.

Types of design models:
- Gesture model
- Conceptual Model
- Structural model
- Ergonomic model
- Mechanical model
- Mass model
- Geometric model (delineating product geometry)
- Appearance model
- Finished prototype

2. Create a culture of and excitement for experimentation, discovery and play. Emphasize real world observation. Have students prove their theories out in the real world.

3. Encourage students to make use of ideas from outside influences. Make frequent reference to the powerful innovation tool of “Technology Transfer”. We have found that students will often shy away from using an idea if they don’t feel that it is 100 percent their own. What has to be made clear to students is that ideas don’t come from thin air. We all are influenced by other designers whether we like it or not. It is to our advantage to be open to surrounding ideas whether they are obtained from discussions with classmates, friends or other existing technologies. The idea is to take ideas from diverse influences and make them our own by using old ideas and combining them in a new way. One of the most powerful design tools is to look at a multitude of product technologies and consider possible applications of concepts to the problem at hand. We refer to this design tool as “technology transfer”. Over the years we have seen students come up with many original ideas in precisely this manor. Most inventions if looked at closely have antecedents or outside influences.

4. Have students become informed as to how things are made by having them pull apart and understand existing products. Reverse engineering can be a powerful learning tool.

5. Encourage students to ask perceptive questions and follow up by asking; “How would these questions be investigated?”

6. Encourage a studio culture that is not afraid to take on technical challenges. The author has had students build a furnace that smelted iron ore and yes we did end up with malleable iron that we were able to fashion tools from. One student of ours created a wind tunnel to analyze the aerodynamics of a vehicle. Granted it was a scaled down wind tunnel but a wind tunnel never-the-less.

7. Allow students room to find their own direction. Once they feel like they own a project and are engaged half the battle is won. Teaching should be a dialogue, a give and take, not a prescription or recipe. Well-worded questions are often better then ridged answers.
Conclusion:

We are living in a time of rapid change. Corporate research and development teams are too slow and burdened to take full advantage of our rapidly changing world. Opportunities for the next generation of independent design innovators will be vast. In order to take advantage of these opportunities designers have to form environments that are conducive to creative thinking. The activity of “tinkering” is at the very core of the creative process. It is a skill-set that has often been abandoned in many design curriculums in recent years. Let’s not let the virtual world clean up our studios to the point that we are no longer exploring design solutions by working with clay, paper, wire, glue, hardware, etc. The activity of tinkering, this wonderful connection between hands, materials and brain is at the very core of the creative process and it is for this reason that it should be preserved and encouraged in our design studios.

Foot Notes:

1 Basalla, George. *The Evolution of Technology*. Pages 66 - 73
2 Henry Dircks, Perpetuum mobile, 2nd ser. (London, 1861), fig. 151, p.40

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