Using a Technical Autobiography to Improve First Year Engineering

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The author has been collecting "technical autobiographies" on the first day of an Introduction to Engineering class for about a decade. This is a primarily undergraduate, liberal arts university and the course enrolls students from across the university. The class is part of a first year seminars program and enrollment is capped at 16.

The autobiography is as an excellent ice-breaker for the class and has provided some interesting information about the prior knowledge and technical background of incoming students. It may also act as an aid for recruitment and retention strategies, as well as general insights into the impact of various K-12 STEM recruitment initiatives.

Some salient conclusions from this data set are that in general students do not come into college with exposure to engineering. The majority of students have not experienced engineering design. Their primary exposure might be through a club-type activity or contest or informal exposure to engineering provided by a relative. Furthermore, the large majority of students do not come into college with significant exposure to what goes on "under the hood" of computers. They are passive consumers of computers and not tinkerers.

I. Introduction

As part of an ice-breaker exercise on the first day of class in an Introduction to Engineering class the author had students complete a "technical autobiography". The current format of that document is shown in Table 1.

Table 1. "Technical Autobiography" Questions
1. Do you feel comfortable using tools? Please describe.

2. Do you ever take machines apart (e.g. bicycles, electronics)?
        ... to fix them?
        ... to see how they work?

3. If you ever wanted to take something apart, but did not, what stopped you?
4. Were you encouraged to experiment with tools and machines as a child? If so, by whom?
5. Have you ever participated in engineering design contests? Please describe.
6. How do you spend most of your time on the computer? Have you ever programmed a computer?

7. What has been your experience with other electronic gaming systems and toys?
8. Have you built or played with kits? (e.g. Legos, models, electronics) Please describe.
9. What interested you in coming to Loyola?
10. What would you like to get out of this course?
11. Complete the following sentence as best you can (there is no right answer!): I learn best when I am   _____.

The questions for this autobiography have evolved over time. They were originally based loosely on prompts from a professional development workshop for teachers with an emphasis on gender stereotypes in STEM. One example of a more general writing prompt is at www.readwritethink.org , searching under the phrase technical autobiography.

After students had time to fill out the autobiography in class quietly on their own we would go around the room and share the responses to the questions. Students were comfortable with that structure and sharing. The author would summarize occasionally for the group what common themes she heard or ask follow-up questions about activities students mentioned. This entire activity takes about 40-50 minutes and is best used as an ice breaker on the first day of class. The author would also share her own technical autobiography about what drew her into STEM and emphasizing the idea that career paths can be wandering and unconventional, but that is probably more common than people may think. The lesson objective is that students get comfortable with each other and the instructor and that they have a positive sense of the diversity of experiences and who might take an engineering class and that there is not an expectation of prior expertise.

II. Results

The results presented here review data from the past two years. This initial data review will help to refine the survey questions as well as how to code various aspects of the response, which are done by hand, on paper and generally open-ended. Some students write more, while others are very terse. There is also some uncertainty in how the students understand some of the survey questions and so they may not think to mention certain play experiences as being relevant (e.g. building blocks). It also appears that some students are more or less able to name family support as encouraging them, even though they may describe familial experiences elsewhere in the survey. In those cases were something was explicitly mentioned ("I worked with dad in his shop") that was counted as encouragement. Data from a few of the autobiography questions are summarized in Table 2 below:

	Q: Experienced a design contest	Q: Comfortable Using Tools	Q: Who encouraged you?			
Table 2. Results from Questions 1,4,5						
Gender				No one	Dad	Other
F(n=9)	55% yes	66% yes		67%	11%	22%
M(n=33)	45% yes	91% yes		30%	37%	33%

Some results and conclusions just from this table are worth emphasizing.

- Women comprise 21% of the sample. That is fairly typical in our engineering program, though the percentages can vary between 15% - 35%. The total sample size is small, because this is a relatively small program embedded in a traditional residential four year undergraduate institution.
- The role of an adult encouraging someone in these pursuits is probably significant. It was surprising that 2/3 of the women did not feel they had anyone encouraging them. The significantly higher percentages of men who felt comfortable using hand tools (91% vs. 66%) and worked with their dad or other (usually male) figure (70% vs.33%) also warrants further investigation of its impact.
- Only about half of all of the students had experienced anything like a design contest (55% female and 45% male).

Table 3, below, summarizes the open-ended descriptions of "engineering design contests" and similar events that the students provided in answer to question 5 on the survey.

Design Contests Description	Number reported	Was the experience extra-curricular?
Table 3. Descriptions of Engineering Design Contests		
Egg Drop	5	
Bridge Building	5	
FIRST Robotics	1	1
Other Robotics	2	1
Project Lead the Way	1	
Sikorsky	1	1
Cub Scouts	1	1
Summer camp	1	1

Table 3. Descriptions of Engineering Design Contests (continued).		
Design Contests Description	Number reported	Was the experience extra-curricular?
Physics class	2	
Mousetrap	1	
Model sailboat	2	2
Fuel car	1	1
Paper tower	2	
Pumpkin Catapult	1	1

Some further details about experiences that students mentioned include the following:

- One or two students had multiple experiences. Most only had a single experience that might be called engineering-related.
- One student mentioned a technology program in middle school,
- Two mentioned computer programming in high school
- One mentioned a technology program in high school.
- One student participated in the national FIRST Robotics program.
- One student participated in the national Project Lead The Way program.
- About 35% of the experiences appear to be extra-curricular. The question was not asked explicitly on the survey and so in some cases may have been inferred by the author. This is something that will be changed in subsequent surveys.

III. Additional Data Analysis

24% of the male students reported that they worked with their father or a male relative on household tasks, cars, or construction, as distinct from being encouraged by them. That 24% represents 8 exposures to tools, technology and manual experience, which is higher than any of the design activities in Table 2.

None of the female students reported that they had that kind of experience. In fact, 33% of the female students had no mention of either a design experience or someone who encouraged them.

In terms of informal exposures to building and creativity through play and games, 70% of the students mentioned Legos by name. In fact their mentions of Legos were tinged with nostalgia and positive emotions mentioning how they played with them all the time or had lots of them. There were other mentions of K'Nex®, and single mentions of Tinker Toys®, Erector Sets®, Bionicles®, LegoNXT®, Lincoln Logs®. There were some mentions of model planes, but only one mention of RC cars. Some of the more unique experiences mentioned included; building sets for theatre, building a real bridge, building a working roller coaster, working construction or carpentry. There were no similar reports of intensive hobbyist experiences in the electronics/computing realm.

Mentions of any significant exposure to electronics, software, or hardware, were scarce with only 21% of all autobiographies reporting something that could be seen as being related to computers, electronics, software or hardware. The author defines "typical" computer use as being reported activities such as watching videos, gaming, social media, research, writing papers. Including those mentions of typical computer use, the percentage rises to 75%. Almost 25% of respondents made no mention of computers in answers to the survey questions. The assumption that incoming college students are "tech-savvy" is likely to be rather misconstrued. Only one student mentioned Arduino® and LegoNXT®, two others mentioned working with hardware, taking apart their laptops or building a computer. Although electronic kits are as available as Legos, they are not a typical part of childhood play and learning.

IV. Conclusions

- Despite efforts to roll out engineering experiences in the K-12 world, the impact of those programs seems to be limited, reaching a small percentage of potential STEM majors.
- Most of the informal exposures to engineering and technology come from the home and in particular the father or another male relative.
- Computers are much more seen as a tool rather than as a hobbyist's plaything.
- Some students are still "lifting" the hoods on cars, but very few have similar experiences in the realm of electronics.
- There are still some mention of other traditional informal educational settings, such as Cub Scouts or Boy Scouts or jobs.
- Women are still under-represented and not receiving the kinds of experiences that would allow them to be on a par with their hands-on male peers.

V. What to do?

It is difficult to know if these results are particular to this educational institution, or where it tends to draw students from (the East Coast) or reflects general trends in American informal culture and K-12 experiences. If they are typical then we are still not effectively reaching the majority of American students formally or informally with exposure and knowledge of engineering. These data can provide ideas for outreach and action, such as more broadly disseminating experiences and programs that have been developed, are well-documented, inexpensive and simple to implement. This would include such things as a paper tower, index card, marshmallow, bridge building, or egg drop contest. Connecting with extra-curricular youth activities may also be a way to have impact. We can expand upon students' early exposure to Legos. A larger challenge is to find ways to expose children to the inner workings of electronics.

The author makes sure that students in this Introduction to Engineering class have the opportunity for "low stakes" experiences with these design contests as well as time to solder a hobbyist's electronics kit. Making sure that the introductory class provides this exposure to everyone hopefully levels the uneven exposure of students to implicit engineering experiences and provides support for retention in the engineering major. Analysis of responses to questions 10 and 11 on the survey may also provide insight into students' expectations and desires.

VI. Future Work

This has turned into a fascinating preliminary study of first year undergraduate student prior experiences with STEM. The technical autobiography will continue to be a first day icebreaker

in Introduction to Engineering. The questions will be revised with an eye towards eliciting responses to some specific questions and where the data can be quickly and accurately coded. Longitudinal tracking may show generational shifts in activities and early exposure to engineering.

A way to engage in follow-up work about which activities, exposures, and supports have the most positive impact on students' retention and perseverance in Engineering will be explored.