Can a Freshman Seminar Serve as an Attractor Course?

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Fundamental changes in student preparation are forcing departments at Berkeley to reconsider their approach to undergraduate education. Simply stated, the word"recruitment" has now entered the undergraduate program's vocabulary. In the past, one expected students to declare their major during the high school application phase, marking them as future mechanical engineers before they ever stepped foot on campus. Although this route certainly is still used, the last few years have seen a marked increase in the number of undeclared students entering the university.

The reasons for this growth are not too difficult to discern. The opportunities for students to experience mechanical engineering in their pre-college years are far more restricted than in prior times and there is no sign that this trend will be reversing any time soon. A very common avenue by which students used to uncover a mechanical engineering interest was through their cars. Turning a wrench on a '64 Mustang sparked an interest in countless students, letting them realize that they enjoyed working on and thinking about *mechanical* systems, something that then aimed them toward mechanical engineering.

As part of the irresistible urge toward efficiency and performance, vehicles have changed in fundamental ways, ways that preclude any real involvement as a "tinkerer." No longer can a student remove a carburetor and start to understand some basic aerodynamics. Modern cars have eliminated them and replaced them with electronic fuel injection. All the engine controls, once accessible to a screwdriver, are now controlled by several on-board processors, each of which is tucked away in a neatly sealed box. Even such a simple thing as wanting to remove a door panel to try and unstick a window regulator is now fraught with peril from potentially exploding air bags. Whereas for the first eighty years of the last century the automobile remained to a very large degree unchanged, over the last quarter century it has grown more akin to a airplane, regulated by computers and moving closer to drive by wire and drive by light technology.

Ironically, many of these changes are due in large part to the efforts of mechanical engineers, who have unknowingly affected the lives of those who might have the aptitude to follow in their footsteps by reducing the opportunities for these young people to discover their own affinities for engineering. As the opportunities for involvement in mechanical systems has diminished so therefore has the student's ability to know whether he or she would prefer mechanical engineering, civil, electrical, and so on. They know they're good in math and science (from their high school courses) but that's the extent of their awareness. Their high

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school counselors will look at their math and science scores and suggest engineering but the students won't have much more of a conception of what engineering really *is* than will the average person on the street.

Many students now respond in a reasonable way to this uncertainty - by seeking admission in the undeclared category and hoping to decide once at the university. But, of course, most of their first courses will be required background in science and math - not engineering.

The problem our department faces is a different one from traditional retention ([1], [2]), in that, rather than trying to retain students who have already declared mechanical engineering as their major, we are trying to steer interested students to mechanical engineering instead of moving into a different branch of engineering. As a way of addressing this issue in a small way, I've turned to the freshman seminar and have offered one each semester for the past six years. Far from being a personal invention, the seminar program at Berkeley was created as a cross-campus offering to help ease first year students into the Berkeley experience and give them a relatively low-stress course within their schedules.

When I first began I gave no particular thought to attracting students to mechanical engineering but simply tried to offer an interesting and fun course. As has been observed [3], students are more apt to feel a motivation to learn if they're enjoying the process. The seminars have covered a range of topics and were originally envisioned, just as those from the rest of the campus, as a way to make Berkeley less intimidating and "user-friendly". Over time, though, the author has noted that students have come to the seminar looking for more than just a low-pressure course. They wished to see more clearly what mechanical engineering, or indeed engineering in general, really is and whether they might be happy entering the field. Eventually I came to realize just how little these students knew of engineering.

Although it often surprises faculty to learn students don't fully understand what a particular engineering major comprises, the fact is that the modern student is very often quite at a loss as to what engineers "do." Because these students haven't had any "real" engineering courses yet and likely will not do so until their Junior year, they have an understandable concern over what they may be getting themselves into. They truly have no conception of the differences between a mechanical engineering or an electrical engineer and, even if they did have some inkling, still don't know whether they'd enjoy doing engineering themselves.

The fact of the matter is that my seminar has evolved over time to provide a new and useful service. It is one of the few avenues that allows a student who is as yet undeclared to dip a tentative toe into the mechanical engineering waters and decide whether such a major might be right for him or her. If the answer is yes, they can start the process of transferring. And, in the case of someone that has already declared their intent to major in mechanical engineering, the seminar provides a way for them to reassure themselves that their decision to major in the field was a good one and to make contact with a professor in a relaxed atmosphere.

As this new raison d'etre for the seminars has appeared, I've reoriented their content to maximize their utility while enhancing the student's enjoyment level (keeping it a fun experience

is still an integral part of the seminar experience). The task as I saw it was to:

- Offer a seminar that appeals to students who might potentially be interested in pursuing mechanical engineering as a profession.
- Structure the seminar so that the students themselves are responsible for some of their own education, a key element of effective learning.
- Highlight a representative array of mechanical engineering disciples so that students can better understand the breadth of the field.
- Increase the students' comfort level and abilities with respect to report generation and public speaking.
- Expose the students to a mild form of research.

In order to develop a cohesive framework for the seminar, I finalized on two particular paradigms of mechanical engineering - the automobile and the bicycle. As the following list reveals, each facet of the field finds expression within some aspect of an automobile.

1. Fluids - Low speed aerodynamics, vehicle resistance to wind gusts, highway vehicle dynamics in the large
2. Dynamics - Vehicle oversteer/understeer, vibration from road/engine, transient lateral dynamics
3. Combustion - Basic process of the Otto cycle, variants such as Wankel engine, hydrogen combustion
4. Controls - Stability control, HVAC automatic climate control, engine management, intelligent cruise control, hybrid operational control
5. Design - Interior and exterior visual design, ergonomic design, structural design.
6. Manufacturing - Robotic assembly, just-in-time inventory scheduling, shared platforms
7. Solid Mechanics - Computational crash testing, tire modeling and design
8. Materials - Lightweight new construction approaches - carbon fiber, aluminum, steel, plastics, replaceable plastic body panels, soft touch materials

Although not as comprehensive an example as the automobile, the bicycle embodies a wide range of engineering disciplines as well and has the advantage of being extremely accessible to college students. Most students own a bicycle and essentially all have had one at some time in their lives. The fact that they're powered by the rider is of significance as it allows me to tie in the power generation aspects discussed in the seminar to the student himself,

i.e. view the body as an engine and draw parallels between the force/hp characteristics of a car with the torque/hp characteristics of a rider.

Some areas of engineering that are exhibited by a bicycle include

1. Aerodynamics - Drafting in bicycle pelotons, skin suits, aero wheels.
2. Materials - Frame materials - steel, aluminum, carbon fiber, titanium
3. Dynamics - Cornering, yaw instability in mountain biking
4. Design - Different design solutions for mountain biking, road biking, downhill biking
5. Design - Kinematic/force considerations of different brake systems.

The foregoing gives just a few of the areas open to discussion. Clearly there exists no lack of potential topics on which to research and speak. Each semester a slightly different mix of topics will, in fact, be touched upon, depending on student and instructor interests.

Now that the basic "what" of the course has been delineated we need to examine the "how." How are these pieces integrated over a semester to motivate and hopefully attract students?

What needs to be created at the start of the class is a thread of continuity that lets the students realize there's a big picture as well as each weekly "little picture." The sequence of seminar discussion topics should reflect this larger framework in such a way that the students can see how each week's work has more completely limned the overall theme of the seminar - in this case automotive-bicycle technology.

The first day of the seminar is used to introduce the philosophy and goals of the course. Being a freshman seminar, and therefore only a single credit course, I've found it to be important to indicate clearly what I'll be expecting of the students over the semester. If any of them were thinking that the course would be no work and an easy pass, they're hopefully disabused of this notion by the end of the hour. This is also when I distribute a sheet of paper listing the possible topics on which they can speak and I ask them to email me with their preferences during the following days. I like to give them a chance to get involved with their own education and by giving them a choice of topics I allow them to target the areas (usually two or three) that they feel would be most interesting. If they have no particular preference, as is sometimes the case, I'll choose for them. In addition, if five people all want to discuss turbocharging technology I'll have to step in and choose the lucky applicant.

Next we will talk about how the topic sequence will create a coherent picture of the bicycle/car applications. The early talks will deal with basic elements, such as the Otto cycles and later ones will move further afield, considering active control technology applied to the entire vehicle's dynamic response, for instance. Finally, I let them know that attendance is an absolute requirement. In most classes the student can pass the tests, not attend the classes, and still pass. That's decidedly not the case here. The class only meets once per week and thus missing a single class is akin to missing a week in a regular class. There's not

time to review past material and so they're informed that lack of attendance will necessarily imply a non-pass in the course.

The second class meeting is a crucial one because it's the avenue through which I indicate how a "good" talk is given. I'll usually present a history of the bicycle and make mention of the elements that are mirrored in cars. The goal, beyond presenting a hopefully interesting talk, is to let the students see how to create slides with the correct amount of material on them, i.e. very little in the way of verbiage and a good deal of graphic imagery that supports the particular points being made in the talk.

Experience has shown that students often have amazingly little experience in giving any sort of effective presentation. They overpower their slides with too many words and too few graphics. They spend their time reading to their audience and don't realize that, with the text already on the screen, they could simply keep quiet and let their audience read.

After this introductory talk has concluded, I lead a short discussion of how the talk was structured - what material was disseminated and how. This gives the students the explicit guidance they need to create their own presentation. The students are reminded at this point that, in addition to the presentation itself, they're responsible for a paper, complete with references. When I first began having students prepare presentations as part of the seminar I didn't require them to do anything beyond the talk itself. Consequently, the level of preparation and research was, to say the least, variable. By requiring a multi-page report, complete with references, they're put on notice that the talk has to be more than simply a cut-and-paste from a webpage.

The talks are limited to 20 minutes or so, leaving room for discussion afterward. Also, interruptions during the talk are encouraged, both to acclimate the students to what a real-world research presentation may someday entail and also to follow up on items of interest while they're fresh in the questioner's mind. If the students don't have any questions I'll either probe deeper into the subject of that week's presentation or take a time-out to discuss some further detail from a prior talk.

The week after a student gives his presentation I'll give him a short written critique, going over both the content of the talk and the quality of the presentation itself. This critique is kept upbeat but if there are points that truly need attention I'll point them out.

I've experimented with the size of the seminar and have found that 12 is optimal. Berkeley has a 15 week semester and 12 students equates to one per week with three left over. Two of these are taken up at the start (the introductory and second meeting), leaving a single "free" class to focus on whatever seems more interesting - a newly released technology, a short introduction to dynamics, or something different.

Now that the class itself has been defined, it's time to answer the question "Does it work?" As far as I can ascertain, the results of the seminar series has been positive on several fronts. Near the end of the semester the students are asked by the department to evaluate the course and these have uniformly averaged out to between 6.5 and 7.0 on a 7.0 scale. Clearly the participants are enjoying the experience, as both the numerical score and written comments

attest. Beyond that, they seem to be getting enough of a positive feeling so as to induce them to join the mechanical engineering department as well. Several students each semester apply for transfer and are usually accepted. I've been giving the seminars long enough now that freshman have moved through the ranks to become graduating seniors and often these seniors will tell me that it was their freshman seminar with me which convinced them to pursue a degree in mechanical engineering. It showed them what they'd eventually be able to do and made it easier to soldier through the required lower-division math and science requirements

One of the common complaints that students make is how they're asked to complete lower-division math and science requirements that seem disconnected from what they actually want to do, namely engineering. My seminar showed them how the differential equations they were encountering would eventually let them analyze the lateral dynamics of a car in a turn, the linear algebra would permit an overall vibration analysis of the sprung structure, the chemistry would undergird the development of stronger plastics, and so on. Previously they would be adrift in a moving stream, unsure of where it would ultimately lead. Now, although still on the same raft, they drift with a knowledge of their ultimate destination and are able to better enjoy the trip and, just maybe, spend a little more attention, knowing that what they learn *will* ultimately be of some utility.

One of the biggest pluses of the seminar for the students has turned out to be the process of researching and presenting their findings. I didn't expect them to appreciate it as much as they do as I initially felt they'd view the documentation and presentation as a burden. But, apparently they're more insightful than I'd given them credit for and realize that these skills are crucial to being a successful engineer.

The only downside to the seminar is that it can only accomodate such a small number of students. By giving it twice a year I can contact around 25 students, half of whom have already declared for mechanical engineering and half of whom are undeclared. Certainly this number can be expanded by the inclusion of additional professors in the program but, to date, such interest hasn't materialized. Although I'm planning to continue this particular seminar in its current form, I'm also considering how a larger offering could be constructed that would capture some of the current seminar's flavor and yet be more easily deployable to larger numbers of students.

References

[1] Demel, J.T., et.al., *Bringing About Marked Increases in Freshman Engineering Retention*, Proceedings, 2002 ASEE Annual Conference and Exposition, Montréal, Québec.

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[3] Kigley, K.A. and Marianno, C.M., *Making Engineering Education Fun*, Journal of Engineering Education, pp. 107, 2001.

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