

# The ‘Bio’-Type Engineering Name Game\*

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*Three traditional engineering communities—agricultural, medical, and chemical—have shown interest in forming undergraduate ‘bio’-type curricula. Nomenclatures for their efforts, however, have been quite variable both in curricula and department names. The agricultural community has the longest track record and also has the greatest variability of names. The medical community has essentially made the name bioengineering synonymous with biomedical engineering. The chemical community is the most recent to enter this endeavor, and has to date shown more efforts with respect to departmental name changes than with curricula name changes. Analyses of recent data collected by the ASABE (American Society of Agricultural Engineers) indicate that ‘Bio’-only names are statistically correlated with increases in undergraduate enrollments. Combination ‘Agr’ and ‘Bio’ names have not yielded significant increases in enrollment, regardless of the ordering of the respective terms.*

**Keywords:** bioengineering; agricultural engineering; curricula names; departmental names

## INTRODUCTION

ENGINEERING academic units have been demonstrating extraordinary activity in recent times in the integration of engineering with applications to biological systems at the undergraduate level. This activity has emerged specifically from three origins: agricultural engineering, medical engineering, and chemical engineering [1]. The efforts to create identity for this activity have resulted in an evolution of numerous and creative naming games for both *departments* and *curricula*.

From its inception in 1905, agricultural engineering curricula have been designed to apply engineering to living systems, particularly with respect to production agriculture. Since the mid-1960s, and particularly since about 1985, agricultural engineering has been experiencing a metamorphosis toward biological applications beyond the farm gate into areas of value-added processing of organic materials, environmental protection and rehabilitation, and protection of health and quality of life.

At the undergraduate level, curricula in medical engineering first emerged around 1965. An extraordinary proliferation of undergraduate medical engineering curricula has occurred since the Whitaker Foundation announced in 1991 its intent to expend by 2005 all of its substantial financial resources (>\$800 million) for this explicit purpose. Between 1995 and 2004, the number of undergraduate medical engineering curricula in the US nearly quadrupled (from 22 to 79)! [1]

Since 1999 the chemical engineering community has also demonstrated a rapidly developing interest in ‘bio’-type engineering. In 2004 21 of 151 (13.9%) US departments of chemical engineering

had adopted *department* names with ‘bio’ in the title [2]. Eleven of these institutions (7.3%) were offering a degree program (*curriculum*) with ‘bio’ in the title.

These three respective communities have responded in different ways to the challenge of defining and naming their ‘bio’-type engineering efforts. The agricultural engineering community has been more prolific in its generation of curricula names, between 12–17, perhaps because of its longer participation in the game. The medical community has basically made synonyms of two terms: biomedical and bioengineering. The more recent chemical community has been mainly changing department names and has been focusing primarily on three terms: biomolecular, biochemical, and biological.

## GATHERING DATA

Data of department and curricula names from agricultural and medical origins were compiled with a study comparing curricula contents in 2002 [1]. The agricultural engineering data were collected in 2002 from the website of the American Society of Agricultural and Biological Engineers (ASABE) [3]. The medical engineering data were derived in 2002 from records of the Whitaker Foundation [4]. In 2004 data for the chemical engineering community were extracted from the AIChE website [5].

In early 2004, a database was compiled of enrollment changes following adoption of ‘bio’-type curricula names for traditional agricultural engineering curricula. These data were derived from a survey compiled by the ASAE Name Change Task Force appointed by ASAE President Robert Gustafson in late 2003. Average yearly

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changes in enrollment were calculated for 37 curricula as follows:

$$\text{Yearly Change} = (\text{Present Yr.} - \text{Previous Yr.}) \\ \div \text{Previous Yr.} \times 100$$

Twelve different *curricula* names were found in this database. These 12 names could be grouped into three categories: Agricultural Engineering; 'Agr' and 'Bio' combinations; and 'Bio'-only names. The 11 'Agr' and 'Bio' combination names had an average longevity of 8.4 years, and the 20 'Bio' only names had an average longevity of 7.5 years. The latest 10 years of enrollment data were used for the 5 traditional Agricultural Engineering names. Repeated measures ANOVAs were run for statistical analyses among the 12 individual names and among the 3 pooled categories of names.

### SO WHAT DO WE NAME THEM?

Names of curricula and of departments are seldom established through the same protocols;

therefore, they are often different. These differences in names, however, are not as prolific for curricula and departments of medical and chemical origin as for agricultural origin, as can be seen readily in Table 1.

In 2002, 80% of the *curricula* of medical origin assumed the name Biomedical Engineering and 20% became Bioengineering. Bioengineering has largely become a synonym for Biomedical Engineering [6]. Some in the medical community consider Bioengineering to be a 'broader' representation to include things like rehabilitation and clinical engineering, yet it is seldom ever interpreted to include areas like agricultural, bioprocessing, bioremediation, ecological, and natural resources engineering. Of the 64 *departments* with undergraduate medical programs in 2002, 75% were named Biomedical Engineering and 20% were named Bioengineering. The remaining 5% had three different names as shown in Table 1. With unprecedented growth of undergraduate curricula during the past five years, there has been a migration toward Biomedical Engineering for both curricula and department names.

Having experienced a transformation from

Table 1. Nomenclature of curricula and departments for agricultural, chemical, and medical origin undergraduate programs (data from 2002 for agricultural and medical and from 2004 for chemical)

Origin	Nomenclature	# Curricula	# Departments
<b>Medical</b>	Biomedical	51	48
	Bioengineering	13	13
	Bioengineering and Neuroscience		1
	Mechanical, Aerospace, and Biomedical Engineering		1
	Biomedical, Industrial, and Human Factors		1
	<b>TOTAL</b>	<b>64</b>	<b>64</b>
<b>Agricultural</b>	Biological Engineering	8	
	Agricultural Engineering	7	2
	Biological Systems Engineering	6	4
	Biosystems Engineering	5	2
	Agricultural and Biological Engr.	4	6
	Biological and Agricultural Engr.	2	8
	Agricultural and Biosystems Engr	3	4
	Bioresource Engineering	2	
	Bioresource and Agricultural Engr.	2	
	Biosystems and Agricultural Engr.	2	2
	Biological Resources Engineering	1	1
	Food, Agricultural, and Biological Engr.	1	1
	Bioengineering	1	
	Bioenvironmental Engineering	1	
	Food and Bioprocess Engineering	1	
	Biological and Agricultural Systems Engr.	1	
	Biomedical Engineering	1	
	Civil Engineering		2
	Biological and Environmental Engr.		1
	Biological and Irrigation Engineering		1
	Biosystems Engineering and Environmental Sciences		1
	Molecular Bioscience and Bioengineering		1
	College of Engineering		1
	Food Science and Engineering Unit		1
	<b>TOTAL</b>	<b>48</b>	<b>38</b>
<b>Chemical</b>	Chemical and Biological Engineering	1	9
	Chemical and Biomolecular Engineering	4	7
	Chemical and Biochemical Engineering	1	3
	Chemical and Biological Sciences & Engr.		1
	Chemical and Molecular Engineering	1	1
	<b>TOTAL</b>	<b>7</b>	<b>21</b>

traditional agricultural engineering to greater biological engineering thrusts, agricultural origin curricula and department names were more diverse than those for the medical origin (which usually adopted the names of their counterpart graduate programs) and the chemical origin. Since the focus of this article is on *curricula*, Table 1 is arranged in declining order of frequency of names for curricula. Incorporation of 'bio-' into agricultural origin curricula names rose from 4% in 1987 to 85% in 2002 [1]. Biological Engineering was used most frequently at about 17% of the time. There were still 15% of the curricula [1] called Agricultural Engineering, yet 3 of these 7 institutions also offered Agricultural Engineering as a companion to their 'bio'-type curriculum. (In 2004 the Agricultural Engineering named curricula declined to five.) Biological Systems Engineering was the third most frequently used curriculum name at 13%, and Biosystems Engineering was fourth at 10%. Thereafter, program names were dispersed across 13 other titles.

In 2002, the most commonly used *department* names in declining order were Biological and Agricultural Engineering (21%), Agricultural and Biological Engineering (16%), and Biological Systems Engineering and Agricultural and Biosystems Engineering (11% each). Other department identities were scattered across 12 other highly diverse names. Only two (5%) of the departments with agricultural origin still retained the department name Agricultural Engineering, and changes appeared likely in their futures! In 1997, Biological and Agricultural Engineering was also the most frequently used department name at 20%, followed by Agricultural Engineering (14%) and Agricultural and Biological Engineering (14%). The remaining department names were scattered across 13 other diverse names. There has truly been a strong transformation in the agricultural community from traditional agricultural engineering toward 'Bio'-type engineering over the last 15–20 years, both in name and in curriculum content [7].

Data in 2004 revealed that 21 of 151 (~14%) accredited Chemical Engineering departments had adopted a 'Bio'-type *department* name [2, 5] and 11 (~7.3%) of these departments offered a 'Bio'-type *curriculum* name. Primarily since 1999, the chemical engineering community has indicated an intense awareness of engineering applications to biological systems. Halford [7] suggested that much of this interest has resulted from declining enrollments in chemical engineering programs with the rapid emergence of medical engineering undergraduate curricula. Of the *department* name changes, Chemical and Biological Engineering has been most frequently adopted (9), followed by Chemical and Biomolecular Engineering (7) and Chemical and Biochemical Engineering (3). In contrast, the most frequently adopted *curricula* name has been Chemical and Biomolecular Engineering (4 of 7 curricula). To date no department

has dropped 'chemical' from its department or curricula name. The relatively recent interest of the chemical engineering community is likely reflected by more activity confined to date in changing department names than in changing curricula names. Organizing transformed content for curricula is more time-consuming than altering department names to reflect new areas of interest. On the other hand, 37 of 151 (~25%) of the accredited chemical engineering departments do reflect options, concentrations, and/or emphases with 'bio'-type nomenclature.

Within the programs of both medical and agricultural origins are numerous names for options, concentration, or emphases. Having often evolved through collaborations of biomedical engineering or bioengineering departments with larger, traditional engineering disciplines, options in medical programs are named bioelectrical, biomaterials, biomechanical, biochemical, and biocomputing. Conversely, electrical, mechanical, material science, chemical, and computer science disciplines offer specializations in biomedical engineering or bioengineering by incorporating additional courses. Other medical program options reflect specializations transferred from graduate level studies to include bioimaging, biomodeling, biotransport, bioinformatics, biofluids, bioelectronics, biomedical signals and imaging, biocontrols, bioinstrumentation/biosensors, clinical, optics, rehabilitation, biotechnology and artificial organs, tissue, cellular and biomolecular, distributed diagnosis and home healthcare, and nanotechnology. The occasionally offered pre-medical, pre-dental, and pre-veterinarian options include medical school requirements for two physics courses, organic chemistry, and two biological science courses.

Option and emphasis names in the agricultural origin programs generally reflect applications broader than human health such as bioenvironmental, bioprocessing, biosystems, biomaterials, bioremediation, bioproduction, natural resources, biotechnology, biological systems, food processing, biochemistry, bioresources, forest, biotechnical, food and biological materials, ecology, aquaculture, pharmaceutical, biomechanics, biosafety, and ergonomics and human factors. Pre-medical, pre-dental, and pre-veterinarian options are also often available through the agricultural origin programs. At least three of the undergraduate programs from agricultural origins offer biomedical curricula: Mississippi State University, University of Missouri, and North Carolina State University.

## DOES NAME IMPACT ENROLLMENT?

A question asked at the 2003 ASABE International Meeting in Las Vegas, NV was, 'Have the academic departments seen an impact on enrollment after changing curricula names to 'bio'-type names?' Consequently, data were collected for curricula from agricultural engineering origin in

Table 2. Average percent annual enrollment change post name change (data obtained for ASABE by Gustafson [8])

Curricula Name	# of curricula	Average annual % change	Standard error	95% confidence interval
Agr Engineering	5	0.6	4.53	(-8.2, 9.5)
Agr & Biological Engineering	4	4.0	5.08	(-6.0, 13.9)
Agr & Biosystems Engineering	2	-1.1	8.10	(-17.0, 14.8)
Agr & Bioresource Engineering	1	2.0	8.99	(-15.6, 19.7)
BioResources & Agr Engineering	1	-3.8	12.46	(-28.2, 20.6)
BioSystems & Agr Engineering	1	-1.0	10.00	(-20.6, 18.6)
Biological & Agr Engineering	1	3.0	9.46	(-15.5, 21.6)
Food, Agr & Biol. Engineering	1	13.5	11.45	(-9.0, 35.9)
Biological Engineering	8	18.1	3.87	(10.5, 25.7)
Biosystems Engineering	7	7.4	4.49	(-1.4, 16.2)
Biological Systems Engineering	5	9.9	4.97	(0.2, 19.7)
Biological Resources Engineering	1	30.2	8.99	(12.5, 47.8)

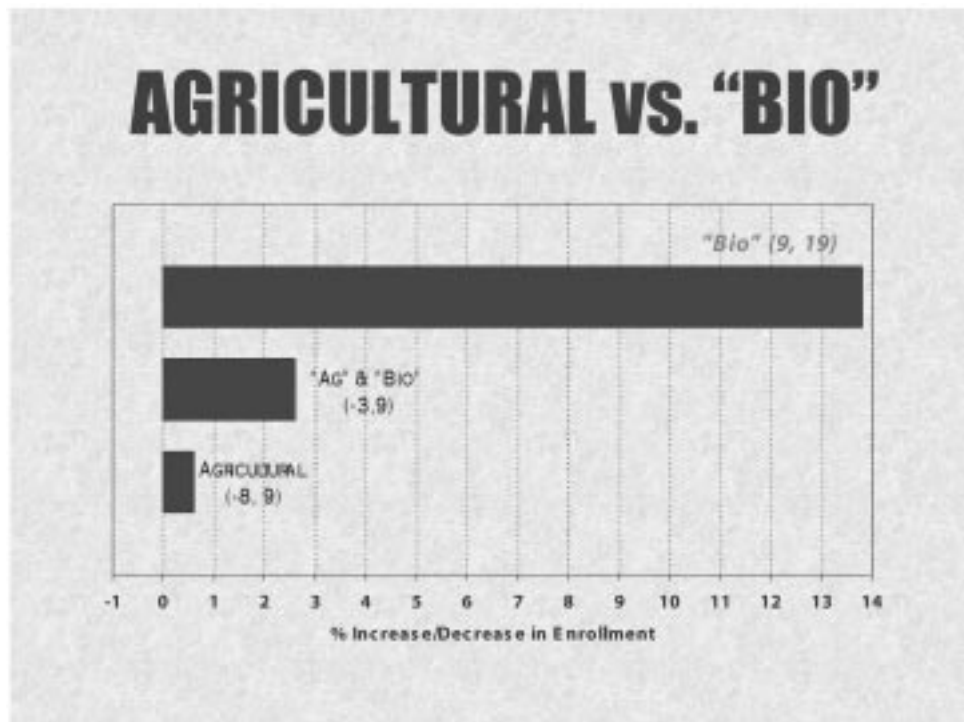


Fig. 1. Relative impacts on percentage annual enrollment changes of three categories of curricula names (data obtained for ASABE by Gustafson[2]).

2003. If similar data have been collected in the chemical and medical communities, they are unknown to the author of this paper.

Table 2 summarizes the average annual percentage enrollment change subsequent to name change for the 12 different curricula names. The pair of numbers in parentheses following each name represents the 95% Confidence Interval that there has been an increase in annual enrollment since the curriculum name was changed. Only three curricula have intervals that do not include zero, indicating 95% confidence of an increase in annual enrollment since the name change. They were all 'Bio' only names: Biological Engineering, Biological Resources Engineering, and Biological Systems Engineering.

Figure 1 compares average annual enrollment changes among 'Agricultural Engineering' versus 'Agr' and 'Bio' names versus 'Bio' only names.

Only the 'Bio' only names had a 95% confidence interval that did not include zero.

The following conclusions can be drawn statistically from these data for agricultural engineering origin programs presented in Table 2 and Fig. 1:

- Curricula titled *Biological Engineering*, *Biological Resources Engineering*, and *Biological Systems Engineering* have had annual enrollment increases since their names were changed;
- In general, curricula with 'Bio' only in their names have had an increase over the traditional curriculum name of Agricultural Engineering;
- There is insufficient evidence to conclude that curricula with both 'Agr' and 'Bio' in their names have had significant increases in enrollment following name change. The order of these two words does not influence whether an enrollment increase is observed.

## IN SUMMARY

Agricultural, medical, and chemical engineering communities have shown interest in forming undergraduate 'bio'-type curricula. There has been, however, considerable variability in their efforts to apply names to their efforts, both for *curricula* and *department* names. The agricultural community has been active longest in offering undergraduate engineering curricula with the purpose of 'bringing engineering to life', yet it has the greatest variability of nomenclature. The medical community has essentially used two names, biomedical engineering and bioengineering, almost synonymously. Being the most recent to enter the 'bio'-type engineering academic

endeavors, the chemical community has to date shown more efforts with respect to departmental name changes than with curricula name changes. Analyses of recent data collected by the ASABE (American Society of Agricultural and Biological Engineers) indicate that 'Bio' *only* names are statistically correlated with increases in undergraduate enrollments. Combination 'Agr' and 'Bio' names have not yielded significant increases in enrollment, regardless of the ordering of the respective terms. Numbers of Agricultural Engineering curricula have declined in the US to only 7 in 2002, and only 5 in 2004. Particularly in the agricultural community, there appears to be a migration toward the term 'biological engineering'.

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