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## Under the ASABE Umbrella — Engineering Degree Programs Need Curriculum Reform

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# Under the ASABE Umbrella — Engineering Degree Programs Need Curriculum Reform

## **Abstract**

The first-ever issue of Transactions of the ASAE, published in 1907, opens with a talk given by Howard W. Riley (after whom Riley-Robb Hall at Cornell University would later be named) that's modestly titled "The Courses in Agricultural Engineering that Should be Offered." Responses from several other luminaries, including J. B. Davidson (after whom Davidson Hall at Iowa State University would later be named), are included and make for fascinating reading for any student or practitioner of our discipline.

## **Keywords**

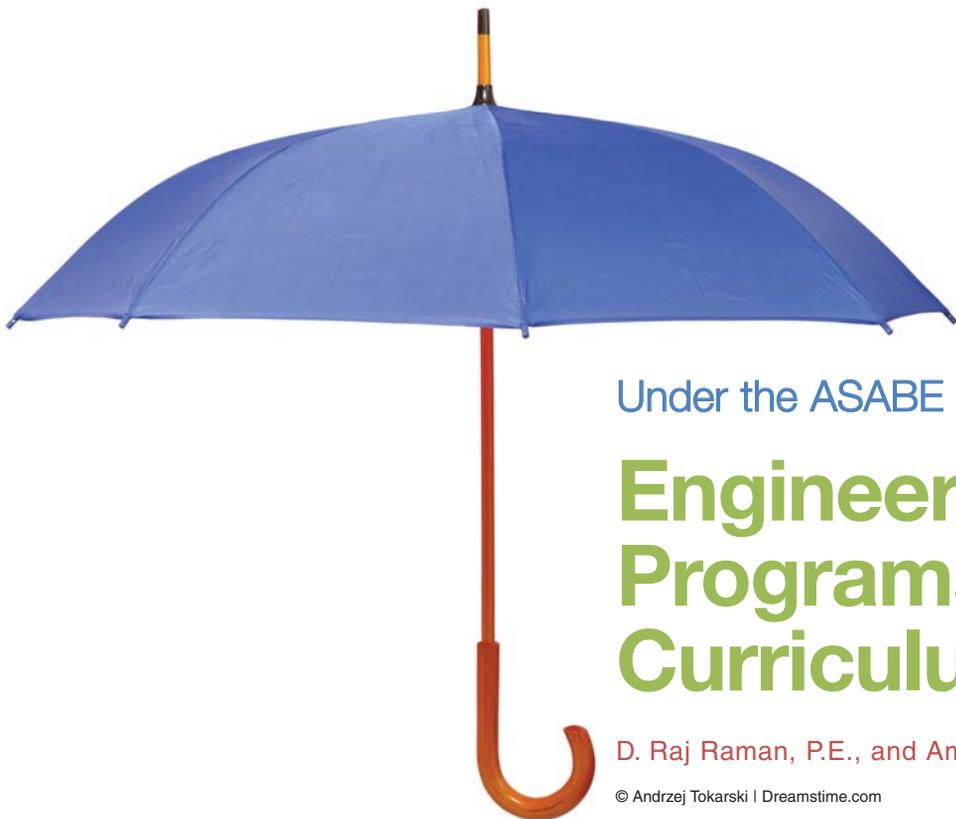
Howard W. Riley, J. B. Davidson, engineering, curriculum, history

## **Disciplines**

Agriculture | Bioresource and Agricultural Engineering | Engineering Education | Higher Education

## **Comments**

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# Engineering Degree Programs Need Curriculum Reform

D. Raj Raman, P.E., and Amy L. Kaleita

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**T**he first-ever issue of *Transactions of the ASAE*, published in 1907, opens with a talk given by Howard W. Riley (after whom Riley-Robb Hall at Cornell University would later be named) that's modestly titled "The Courses in Agricultural Engineering that Should be Offered." Responses from several other luminaries, including J. B. Davidson (after whom Davidson Hall at Iowa State University would later be named), are included and make for fascinating reading for any student or practitioner of our discipline.

Riley describes the fundamental curricular challenge for our discipline thusly: "Our field is a broad one, our subjects cover work that ordinarily is divided between a number of colleges." He gives a nod to the need for local conditions to inform courses, noting in particular that drainage and irrigation coursework should be "more or less extended according to the requirements prevailing in the state." He also expresses the value of hands-on learning, saying: "[the student] will himself take a few simple examples of practical work right thru the different stages of their design and manufacture, thereby getting much clearer ideas of the different steps than he would get if he drew things that he never made and made things that he never drew."

Riley goes on to explain that we should strive to provide our students with equal parts of self-reliance, common sense, ingenuity, and technical information so that they might be "provided with the best possible equipment for meeting the great variety of special problems" that they will eventually face. According to Riley, our core knowledge base should be built on courses in drawing, shop work, farm machinery, farm motors, field engineering, and rural architecture. In response, several commentators noted the similarities between Riley's vision and the curricula that they were offering at their own

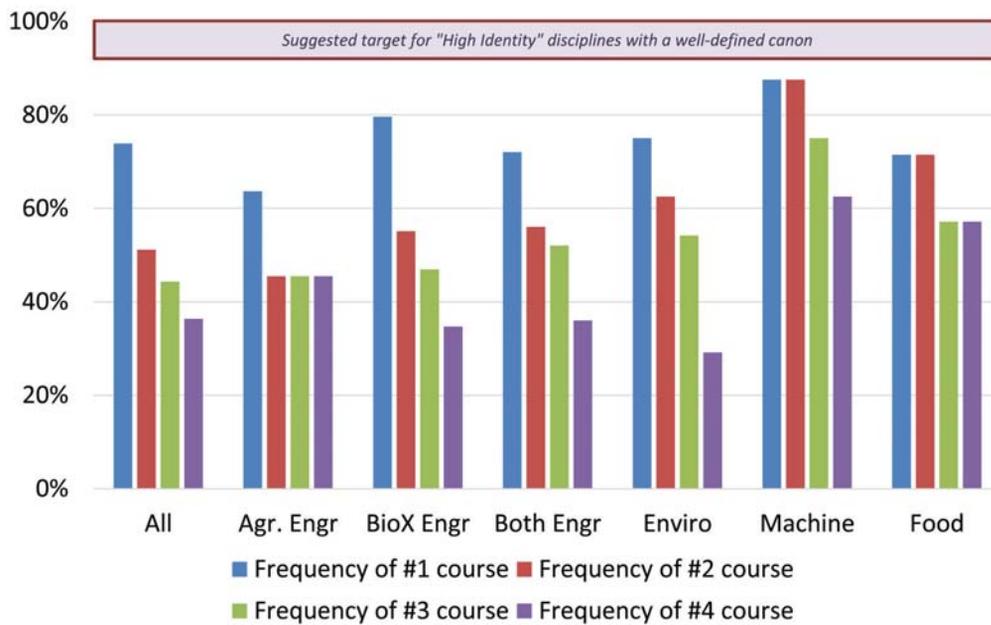
schools, although Professor John Evans (of Ontario Agricultural College) dissented slightly, saying: "Conditions vary and ... no hard and fast course can be formulated."

Leading the discussion, Davidson agreed that there were many similarities, and concluded his comments with a recommendation: "A committee should be appointed at some future time to canvass the various institutions offering instruction in any of the branches of Agricultural Engineering and make a report to the Society covering the courses taught and the hours of class room and laboratory work allotted to each course."

## One hundred years later

In the December 2012 issue of *Transactions of the ASABE*, we reported on the variation in the curricula of agricultural engineering, biological engineering, and similar academic programs. We undertook that work unaware of the conversations that took place long ago at the first meeting of our Society, but we were motivated by the same goals set forth by J. B. Davidson, namely, to attempt to canvas and summarize the state of the curricula in the academic programs that serve our broad discipline. For simplicity, we called these various programs "ASABE-umbrella programs" because they're all represented by the diverse membership of our Society.

What we found was not surprising. Although the academic programs that we evaluated share many core math, science, and basic engineering courses, the commonality drops off rapidly at the discipline-specific level. Furthermore, our analysis showed that the program names do not map clearly to the contents of their curricula. Since that earlier article appeared, we've received many thoughtful comments from colleagues in academic departments across the country. Several of them encouraged us to extend our analysis to



Frequency of the top four discipline-specific courses by academic program name: “All” represents all ASABE-umbrella curricula, “Agr Engr” represents curricula within programs called agricultural engineering, “BioX Engr” represents curricula within programs called biological engineering (or biological systems engineering, etc.), and “Both Engr” represents curricula within programs called agricultural and biosystems engineering (or biological and agricultural engineering, etc.). The last three groupings (environment, machine, and food) are common options within many degree programs, regardless of the program name.

describe the degree of commonality in discipline-specific coursework (that is, outside of core math, science, and engineering courses) when programs are grouped by name.

In our earlier article and here, we defined an academic program as any unique set of required courses. Depending on the institution and degree, it may be a degree program or a defined option with unique course requirements within a major.

The above graph shows our analysis broken down by academic program name. For reference, the top four courses in each program type are defined in the table on the next page. The results of this additional analysis confirm that the lack of commonality across the entire discipline (i.e., the first grouping in the graph) is more than just a symptom of the multitude of options offered. Even within specific options, we have significant diversity in course offerings. Bluntly put, other than general engineering topics, our discipline lacks a canon.

### The path forward

The path that led to this collection of eclectic curricula has been complex. The agricultural crises of the 1980s made it challenging for many programs to maintain viable student numbers. Shifting demographics and agricultural practices, as well as differing visions regarding the mission and scope of the discipline, also played a role. However, the 21st century has brought enrollment growth to many of our pro-

grams. A multitude of factors can be credited for this growth, including recognition of the importance of renewable energy and materials for sustainable human development, a realization that global population trends will increase the demand for food, clean water, and perhaps bio-based transportation fuels, and a job market that values the systems perspective that our graduates can apply to engineering projects.

Some of this growth may also have been driven by the quality of education provided by typical ASABE-umbrella programs. For reasons about which we can only speculate (e.g., maybe Howard Riley’s valuing of hands-on problem solving has become part of our curricular DNA), ASABE-umbrella programs

are often a locus of outstanding engineering education on their campuses. As a result, just over a century since its founding, our discipline finds itself in the slightly paradoxical situation of strong student enrollment in highly disparate curricula.

This curricular diversity may contribute to a lack of identity that is not in the best long-term interest of the discipline. We believe it is time for a discipline-wide conversation about the costs and benefits of these disparate curricula, and about the potential value of defining and teaching an agreed-upon common core of courses. As we noted in our earlier article, diverse curricula have many advantages: they reflect the needs of regional stakeholders including employers and graduate programs, they fit the capabilities of the teaching faculty, and they mesh with the academic environment at a specific university. But this disparity in curricula also makes it hard to know exactly what a graduate of one of our programs can do, and this creates confusion in the minds of prospective employers, recent graduates, and even the faculty themselves. Therefore, to improve the long-term health of our discipline, we propose the following three-pronged approach:

1. Request that ASABE Committee ED-210 (Academic Program Administrators) promulgate a series of specific curricular proposals that broadly define our discipline. This will start the discipline-wide conversation that we need.

2. Provide an undergraduate engineering education that emphasizes the synergism between theoretical knowledge

Program Name	No. of Programs	Top Four Discipline-Specific Courses in Order of Frequency			
		First Course	Second Course	Third Course	Fourth Course
All Programs	88	Instrumentation and controls	Engineering properties of biological materials	Applications of mass and energy balances in ag and bio systems	Natural resource engineering
"Ag" Programs	11	Instrumentation and controls	Applications of mass and energy balances in ag and bio systems; Machinery systems; Natural resource engineering		
"Bio" Programs	49	Instrumentation and controls	Engineering properties of biological materials	Applications of mass and energy balances in ag and bio systems	Natural resource engineering
"Ag and Bio" Programs	25	Instrumentation and controls	Engineering properties of biological materials	Process engineering	Applications of mass and energy balances in ag and bio systems; Natural resource engineering
Environment (soil and water)	24	Natural resource engineering	Instrumentation and controls	Engineering properties of biological materials	Applications of mass and energy balances in ag and bio systems; engineering analysis of biological systems; Nonpoint-source pollution
Machine	8	Instrumentation and controls; Machinery systems		Engineering properties of biological materials	Natural resource engineering
Food	7	Instrumentation and controls; Engineering properties of biological materials		Food Engineering Biological reactors	

and practical application. This will translate into a virtuous cycle of increasing enrollment and strengthening placement opportunities for graduates.

3. Continue to hire faculty members from a wide range of disciplines—we are unusual in engineering academia in this regard—and be more effective at integrating them into our discipline and into ASABE. This will build on our current strengths.

In regard to proposal item 1, let's define a concise, but broadly acceptable, core knowledge base for the discipline. There should be at least one full semester (e.g., 12 to 15 semester hours equivalent) of discipline-specific coursework taken by students in all ASABE-umbrella programs. This represents a significant increase over the status quo, in which only two discipline-specific topics, equivalent to maybe six semester hours, are required in more than half the programs. This is not to argue that every graduate of an ASABE-umbrella program should be a power and machinery expert, or a soil and water expert, or a bioprocessing expert. Instead, it's intended to achieve a degree of commonality in undergraduate training across the discipline. We regularly require a similar amount of common coursework for minors at our institutions. Why not do the same for majors?

Our discipline is characterized by its unique embrace of biology and engineering in the context of natural resources production and protection. Our graduates should have experience with engineering approaches to biological systems ranging in size from microscopic to field scale, and they should

be trained to make linkages across those scales. They should be familiar with instrumentation because our discipline relies on instrumentation in systems ranging from compost piles to UAVs, and because our instrumentation courses offer a unique opportunity to integrate multiple engineering concepts. With this in mind, here are four courses that might serve as a core for our discipline:

- Mass and energy balances in biological systems.
- Engineering properties of biological systems.
- Instrumentation and control applications in biological systems engineering.
- Ecological applications of soil and water engineering.

Our degree programs at Iowa State University do not include all of these courses, so it is not our intent to suggest that the common core is simply whatever we are currently doing at our campus. Instead, we propose these courses based on the results of our curricular analysis (many departments already offer similar courses) and because we believe that these courses provide a knowledge base that can be used in virtually all of the programs within our discipline.

Once ED-210 has developed its proposals, a consortium of stakeholders could review the proposals and make recommendations to the Society. The consortium could comprise key educational committees and employers across a range of industries. If ratified, each proposal could be codified into the ABET programmatic requirements for both "agricultural" and "biological" engineering degrees—although it seems

unlikely that the multiple societies that inform biological systems engineering degree requirements would be amenable to such a change. It might be more realistic to offer an ASABE-ratified recommendation for a core curriculum, which would serve as a target to which programs would aspire, rather than a requirement for accreditation.

In regard to proposal item 2, although we didn't collect data on hours of lab exposure for each curriculum, we believe that many ASABE-umbrella programs emphasize hands-on problem solving, and we also believe (based on our experience at Iowa State) that this trait is highly valued by employers. In fact, we believe that our discipline is uniquely positioned to provide clear linkages between theory and practice, and we should harness this strength in the service of the discipline, and of engineering education in general.

In regard to proposal item 3, executing proposal 1 will greatly facilitate this effort. We believe that it's crucial that the majority of faculty members in ASABE-umbrella programs consider themselves part of our discipline, and part of our Society, whatever their individual area of specialization.

This effort to "normalize" our academic curricula will take deliberation, time, and compromise—and it could make for some hurt feelings. It is certainly easier to live with the status quo and leave things as they are. However, this is not a discipline whose practitioners turn away from challenges. And given the grand challenges that the world is facing, the status quo just won't do. Our discipline has crucial contributions to make in the coming century, and educating the next generation of capable, practical, versatile engineers could be the greatest contribution of all. Let's get on with it.

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*The authors—along with other faculty members from across the United States and Canada interested in curricular issues—will be presenting on related topics at the AIM, Advancing the Core Curriculum in Biological Engineering special session, Monday, July 14, organized by Professor Ashim Datta of Cornell University. Check the AIM agenda for place and time.*

### For Further Reading

Garrett, R. E. 1991. What's in a name? *Agricultural Engineering* 72(March): 20-23.

Kaleita, A. L., and D. R. Raman. 2012. A rose by any other name: An analysis of agricultural and biological engineering undergraduate curricula. *Transactions of the ASABE* 55(6): 2371-2378.

Riley, H. W. 1907. The courses in agricultural engineering that should be offered. *Transactions: The American Society of Agricultural Engineers* 1(1): 5-14.

## Examples from other engineering disciplines



As examples of how other wide-ranging, industry-oriented, engineering disciplines organize themselves, here are the 2013-2014 ABET program criteria for aeronautical engineering and architectural engineering and for two degrees that are within ASABE-umbrella programs.

### Aeronautical Engineering

Aeronautical engineering programs must prepare graduates to have knowledge of aerodynamics, aerospace materials, structures, propulsion, flight mechanics, and stability and control. Astronautical engineering programs must prepare graduates to have knowledge of orbital mechanics, space environment, attitude determination and control, telecommunications, space structures, and rocket propulsion. Aerospace engineering programs or other engineering programs combining aeronautical and astronautical engineering must prepare graduates to have knowledge of aeronautical engineering or astronautical engineering, as described above, as well as knowledge of some topics from the area not emphasized. Programs must also prepare graduates to have design competence that includes integration of aeronautical or astronautical topics.

### Architectural Engineering

The program must demonstrate that graduates can apply mathematics through differential equations, calculus-based physics, and chemistry. The four basic architectural engineering curriculum areas are building structures, building mechanical systems, building electrical systems, and construction and construction management. Graduates are expected to reach the synthesis (design) level in one of these areas, the application level in a second area, and the comprehension level in the remaining two areas. The engineering topics required by the general criteria must support the engineering fundamentals of each of these four areas at the specified level. Graduates are expected to discuss the basic concepts of architecture in the context of architectural design and history.

### Agricultural Engineering (and similarly named programs)

The curriculum must include mathematics through differential equations and biological and engineering sciences consistent with the program educational objectives. The curriculum must prepare graduates to apply engineering to agriculture, aquaculture, forestry, human, or natural resources.

### Biological Engineering (and similarly named programs)

The curriculum must include mathematics through differential equations, a thorough grounding in chemistry and biology, and a working knowledge of advanced biological sciences consistent with the program educational objectives. The curriculum must prepare graduates to apply engineering to biological systems.