AC 2009-448: DEFINING ARCHITECTURAL ENGINEERING DESIGN

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Defining Architectural Engineering Design

Abstract

The question of what constitutes "Architectural Engineering Design" (AED) is addressed through an online survey of representative faculty at ABET accredited Architectural Engineering schools. The faculty are first characterized in multiple ways: university, academic rank, years of experience, registration status and discipline. The results of their open-ended definition of AED are examined using eight categories derived from the responses rated on 1-5 Likert scales, with the analysis broken down using the same faculty characterization. Faculty opinions about the disciplines necessary to include in AED are also analyzed. Overall there is general agreement that disciplinary "skills" are an important part of AED as are, to a lesser extent, the "products" produced. There is some agreement about the idea of "integration" of the disciplines and much less agreement on many of the other concepts, with several barely mentioned. Most faculty feel that their definition of AED is the same as their school's, but many express uncertainty about the existence of a national definition. Similarly there is considerable agreement that more than one discipline (Architecture, Structure, HVAC, Electrical, Construction Management) is required to constitute AED, but there is marked disagreement about what specific ones should be included, with opinions ranging from two to all five.

Introduction

Design is what most of our graduates do. Some, of course, will work constructing other's designs, funding and approving designs, or perhaps analyzing the successes and failures of the design process. Design in its many facets is the heart of the Architectural Engineering (AE) profession. All the tools of mathematics, the sciences, communication, and the varied analytic methods of the disciplines in which our students specialize are chosen to support and enhance the design process and product.

How we teach design for Architectural Engineers is the subject of a year-long study that I've undertaken as a sabbatical project. In the literature there are many papers addressing specific aspects of design classes, particularly freshman and capstone design, as well as some looking at the entire curriculum. There is also a vast literature about general engineering design, addressing everything from the latest theories in the learning sciences to highly practical "how-to" books[1][2][3]. A literature search failed to find an overview on how the accredited schools of Architectural Engineering in the US define Architectural Engineering Design (AED), who teaches it, what methods are used to teach it, and what are the issues that those who teach it regard as important. This paper, probably the first of several, addresses the questions: what are the characteristics of those who teach AED; how do they define it; which disciplines should be included in an AED course?

The work presented here uses data from an online survey completed by a fairly complete sample of faculty at all the AE schools (the data in this paper represents about ½ the schools and will be updated at the ASEE conference). It breaks that data down in a variety of ways, and presents some opinions and conclusions. It shows some areas of agreement, quite a range of opinions,

and areas deserving attention. The most general conclusion is that the definition of Architectural Engineering Design is worth considering at the National, School and individual level.

Approach taken – a survey of faculty only

There are many stakeholders in the education process: students, administrators, employers, funders and of course faculty. This study focuses on faculty for several reasons. The first was pragmatic: they were accessible and interviewing them both in person and online was feasible within the scope of a one-year individual project. Because human subjects approval for the survey was necessary, it would have been far more difficult to receive approval in a timely manner had students been the subject, not to mention the difficulties of framing questions in an appropriate manner given the greater language and experience difference.

The second reason is that the faculty set the curriculum and make the fundamental decisions about the scope of, and approach to, the content. In essence the study address the question of what do those who make the curricular decisions deem important, without addressing the equally important question of how successful they are at imparting the content.

More particularly, this paper reports on the partial results of a survey taken by faculty at the schools being visited. Further reports will address the results of the interviews as opposed to those from the survey, but the survey results are far more controlled and lend themselves to detailed analysis.

How it might benefit the profession

As the results below show, there is some general agreement about the ingredients of architectural engineering design, but there are a number of areas where concepts that I would argue are important are not considered, or there is explicit disagreement. Isolating these agreements and disagreements for public discussion may improve both what is considered appropriate for architectural engineering design and potentially the way it is delivered, with consequent benefit for students, faculty and the general public.

Completion Status

As noted above, the results presented here represent surveys completed from approximately 1/2 of the architectural engineering schools in the US. They will be updated with the full complement of schools by the time of the ASEE conference. They may also be available on my sabbatical [9].

Results – Major Groupings

In the results section below there are three major groupings.

- Faculty characteristics
- Analysis of the definition of architectural engineering design
- Disciplines essential to architectural engineering design

Methodology

Survey

As noted above, the results presented here are the results of an online survey addressing a number of issues related to architectural engineering design education. While I have attempted to ensure the quality of the survey, it has limitations delineated below.

The survey had only four required questions, those necessary to categorize the individuals: University; disciplines that the department includes; academic rank; primary discipline. All other questions were voluntary. There was one open-ended question on the definition of architectural engineering design. Most others were checkboxes or single-line answers (e.g. course title). For each group of questions respondents had the opportunity to leave open-ended comments if they chose.

Response Rate - Site Visits and Departmental Interviews

An online survey of this length (18-screen) is daunting indeed to most people. The response rate for an unsolicited survey is typically around 1-20% for a "general public" survey, and 5-40% for "customers and members" [10]. So far I have interviewed 87 faculty members and have received survey responses from 60, a 69% response rate. Although there is not a one-to-one correspondence between the interviews and those who take the survey, because 22% of those who took the survey opted for anonymity, those who identified themselves are essentially those that I interviewed.

Coding Method

One major portion of the results presented below relies on "coding" an open-ended response to the question "What is your definition of Architectural Engineering Design?" The method I used was to first review all of the responses to that question, developing "themes" from each of the questions. Then, following the ethnographic qualitative research methods I grouped those themes into a representative subset, nine in total [11][12]. Sseveral of those themes have very low response rates and are therefore not statistically significant in their specific answers, but seem to me to indicate areas where there might be beneficial discussion.

Each theme was given a one line definition which was referred to throughout the coding process – they are given in that section of the report. Each of the respondent answers was categorized on a Likert scale from strongly negative (1), to strongly positive (5). A value of three indicated that the theme was mentioned or implied in the definition, but was not significantly emphasized.

This coding method is subjective and good research technique would have a second coder independently code the same material with subsequent checking for agreement and resolution of

differences. A second coder was not available and there were concerns about subject privacy. I did review each response twice in addition to the initial quick theme-identification pass to minimize this difficulty.

Validity of the survey instrument

As with the coding method, the construction of the survey was as rigorous as possible, but could be improved. There were four versions of the survey generated before the final version. One almost-final version was reviewed by the University's human subjects committee. Another version was reviewed by a psychologist colleague who raised substantial questions that were addressed. A near-final version was given to two colleagues who provided feedback that shaped minor changes.

Respondents were given the opportunity for almost every question to comment on the question. They were also given the opportunity to comment on the survey overall at the end. There were almost no comments identifying ambiguities in the question, and there were several commendations in the overall comments on the appropriateness of the survey.

Are the Responses Representative?

By the end of this project I will have visited 100% of the accredited architectural engineering programs in the United States (17 as of 1/2008 when visit plans were fixed). The survey therefore is comprehensive in its population, although the sampling of that population is voluntary rather than the ideal of a random selection. Because the response rate is high there is a reasonable chance that this is close to a representative sample.

When visiting the schools the faculty I interviewed were chosen by the department or program head rather than me. The request to the visit coordinator was that they include those architectural engineering faculty responsible for architectural engineering design, and also faculty offering allied courses such as discipline-specific design courses and analytic courses. Of course some individuals were unavailable, but I believe that I met and solicited for the survey the vast majority of appropriate faculty.

Are the Responses Significant?

In the tables that summarize most of the responses it is important to check the "count" of responses given in the left-hand column. In many cases this count is quite low and therefore the likelihood of a particular number being statistically significant is equally low. Since the major benefit of this work is likely to be promoting discussion in the community it is worth presenting all of the numbers despite the current lack of statistical analysis.

The tables have been shaded to highlight those responses that I believe merit specific consideration. All lines where the number of responses is two or less have been shaded no matter what the numbers for the individual columns. In other cases a somewhat arbitrarily cutoff point makes all cells 3.6 and below gray in order to highlight those with greater emphasis.

Faculty Characteristics

The first group of results addresses the characteristics of those who responded to the survey. As presented in the above section on representation, it is reasonable to believe that this is close to an

overall picture of the faculty who teach architectural engineering design and areas related to architectural engineering design.

Count by Rank of respondents

Univ	Professor	Assoc. Professor	Assistant Professor	Instructor	Adjunct	Other (please specify)	Grand Total
Cal Poly San Luis Obispo	1	4	3				8
Drexel University	2	3	2			1	8
Illinois Institute of Technology			1				1
Missouri University of Science and Technology	1		2			1	4
North Carolina A&T State College	2	1	1				4
Other (please specify)			1				1
Penn State University	2	5					7
Tennessee State						1	1
University of Colorado	4		3	1	1		9
University of Kansas	2	3	1	1			7
University of Nebraska - Lincoln	1	1	1				3
University of Wyoming	3	2	2				7
Grand Total	18	19	17	2	1	3	60
Pecercent	30%	32%	28%	3%	2%	5%	100%

Table 1- Count of Respondents by University and Academic Rank

Comments

- The rankings are as the respondents chose to provide them.
- Most of those who are categorized as "other" should probably be characterized as "instructor". There is considerable variation in terminology between institutions for these categories.
- The number of survey responses by institution is generally representative of the Department size of the institution with only Missouri being somewhat low.
- Note that all the programs presented here offer undergraduate accreditation of the AE degree with the exception of Nebraska, which has a bachelor's/masters program with the masters program being the accredited one (others to be included later also include at least one with a masters accreditation).

Teaching Experience

Univ	Professor	Assoc. Professor	Assistant Professor	Instructor	Adjunct	Other (please specify)	Grand Total
Cal Poly San Luis Obispo	12	10	5				8
Drexel University	15	5	4				8
Illinois Institute of Technology			10				10
Missouri University of Science and Technology	22		7			13	12
North Carolina A&T State College	23	29	10				21
Other (please specify)			15				15
Penn State University	16	15					16
Tennessee State						34	34
University of Colorado	20		3	8	28		14
University of Kansas	20	11	4	0			11
University of Nebraska - Lincoln	18	21	3				14
University of Wyoming	20	22	5				16
Grand Total	19	14	6	4	28	24	13

Table 2 - Average years of teaching experience

Comment

- The count on several of these items is fairly low so the averages in those case are not particularly meaningful. In particular there are single responses for both IIT and Tennessee state, neither of which I have not yet visited.
- For both Cal Poly and Drexel it would appear that there are responses from younger faculty members, lowering the overall level of experience. Based on my visits to the institutions both appear to be somewhat unrepresentative of the overall faculty although both are engaged in hiring faculty.

Teaching AE Design Experience

Univ	Professor	Assoc. Professor	Assistant Professor	Instructor	Adjunct	Other (please specify)	Grand Total
Cal Poly San Luis Obispo	12	9	3				8
Drexel University	0	4	0			20	5
Illinois Institute of Technology			6				6
Missouri University of Science and Technology	0		5			13	6
North Carolina A&T State College	18	29	10				19
Other (please specify)			3				3
Penn State University	16	13					14
Tennessee State						30	30
University of Colorado	15		2	2	26		11
University of Kansas	2	7	3	0			4
University of Nebraska - Lincoln	15	21	3				13
University of Wyoming	15	0	2				8
Grand Total	12	11	3	1	26	21	9

Table 3- Average years of teaching AE design

Comment

- This is a self-identified group, which is particularly relevant since the definition of AED is not agreed upon.
- The total count for this group is 53 so most of those surveyed believe that they have experience teaching AE design.

Industry Experience

Univ	Professor	Assoc. Professor	Assistant Professor	Instructor	Adjunct	Other (please specify)	Grand Total
Cal Poly San Luis Obispo	7	12	12				11
Drexel University	0	24	2				10
Illinois Institute of Technology			8				8
Missouri University of Science and Technology	0		12			5	7
North Carolina A&T State College	6	7	30				12
Other (please specify)			1				1
Penn State University	17	18					18
Tennessee State						5	5
University of Colorado	4		2	10	7		5
University of Kansas	3	0	6	0			2
University of Nebraska - Lincoln	23	8	12				14
University of Wyoming	10	3	3				6
Grand Total	7	11	8	5	7	5	8

Table 4 - Average years of industry experience

Comment

- Count of 55 – a somewhat surprising number after the interviews, although this does count contain several instances of "0" years which would lower the average.
- It would be intriguing to compare these numbers to other engineering departments. The expectation would be that these are higher.

Professional Registration

Univ	Professor		Assoc. Professor		Assistant Professor		Instructor		Adjunct		Other (please specify)		Total Count of Reg PE	Total Count of Reg RA
	Count of Reg PE	Count of Reg RA	Count of Reg PE	Count of Reg RA	Count of Reg PE	Count of Reg RA	Count of Reg PE	Count of Reg RA	Count of Reg PE	Count of Reg RA	Count of Reg PE	Count of Reg RA		
Cal Poly San Luis Obispo			4		3								7	
Drexel University			2								1		3	
Illinois Institute of Technology					1								1	
Missouri University of Science and Technology	1				1	1					1		3	1
North Carolina A&T State College	2					1							2	1
Other (please specify)					1								1	
Penn State University	2	1	3	1									5	2
Tennessee State														
University of Colorado	4				1								5	
University of Kansas	2		2	1			1						5	1
University of Nebraska - Lincoln	1		1		1								3	
University of Wyoming	3		1										4	
Grand Total	15	1	13	2	8	2	1				2		39	5

Table 5 - Professional Registration

Comment

- There are two individuals with dual PE/RA registration
- A number of individuals reported other kinds of registration/certification – e.g. surveying, LEED etc.
- This data should be available from ABET self-studies in more detail and could be used to check the representative nature of these respondents. The year of the self-study varies, however so there would be inaccuracies there.

Discussion of the results

There are no big surprises in these characterizations of the faculty. It is nonetheless worthwhile to know the background against which the opinions about teaching AE design is set.

Definition of Architectural Engineering Design

In the survey the first question asked after the respondents had characterized themselves was "What is your definition of Architectural Engineering Design?" The overall characteristics of the answers are:

- Length range from 2 words to 127 words
- Average length 31 words

Legend

In the tables that follow the coding was performed as described above. The specific terms used in the coding (not known to the respondents) were as follows:

Value	Meaning
1	Emphasis Negative
2	Negative
3	Mentioned
4	Positive
5	Emphasize Positive

Table 6 - Rating scale used for AE Design definitions

Label on Results	Definition used when coding
Concepts	Addresses the concepts that produce or are essential for AE Designs - distinct from values
Differentiation	Differentiates AE Design from other kinds of design
External References	Refers to other definitions of AE Design
Integration	Addresses integration between the disciplines including Architecture
Miscellaneous	Addresses issues not covered by the other rating scales.
Process	Addresses the processes of AE Design - distinguished from specific skills
Products	Addresses products of AE Design including calculations; models; physical reality.
Skills	The skills necessary for AE Design - including discipline-specific skills, analysis, communication, teamwork etc.
Values	Considers values and goals that AE Design should or does address.

Table 7- Categories used for AE Design definitions

Comment on the categories

- As noted in the methodology section these categories were determined as a result of reviewing the AE definitions submitted by the faculty. They were informed by my reading of the learning sciences literature but do not directly to refer to any concepts that are current in that literature.[3]

Overall – Design category average ratings for the entire sample

Overall		Count	Concepts	Differentiation	External Reference	Integration	Miscellaneous	Process	Products	Skills	Values
	Count	60	7	43	1	31	8	18	17	48	15
	Count Percent		12%	72%	2%	52%	13%	30%	28%	80%	25%
	Overall Avg		3.7	3.0	3.0	3.6	3.1	3.4	3.8	4.2	3.5

Table 8 - Design category average ratings overall

Comment

- The rationale for the shading in this and the other tables analyzing the design definitions is explained in the section "Are the responses significant?" above.
- In the "count percent" line the meaning of the shading is varied to show any rate greater than 50%.
- In this and therefore the other tables that follow the *skills* category as the highest response rate and the highest rating. This is unsurprising because I included in this category all of the discipline-specific skills that get students jobs on graduation.
- Even though the count for the *products* category is much lower it represents the same kind of job emphasis as the *skills* category.
- *Differentiation* is the second highest response, but has a low overall rating. In general faculty didn't spend much time differentiating AE Design from other disciplines, but if they mentioned "building" or some similar term in the definition that indicated a restriction on the general design approach I gave a rating of three.
- In one or two cases people explicitly stated that AE Design is no different than other design approaches.
- Note the very low response rate in two categories: *concepts*, *external reference*. Any results in these categories are not statistically significant. I included them, however, for the following reasons.
    - *Concepts* represents the ideas or principles that are being imparted or used in the AE design process. In discipline courses there is often significant emphasis on concepts or principles. It seems striking that this kind of emphasis is absent in discussions of design.
    - *External reference* would seem to be appropriate for a definition, whether it be from a dictionary or from ABET. That only one person included an external reference may just represent the hurried nature of taking the survey. It's conceivable however that it represents a larger issue of a lack of common agreement in the field.

By Average Years of Experience Design – 3 types

Years Teaching Experience	Count	Concepts	Differentiation	External Reference	Integration	Miscellaneous	Process	Products	Skills	Values
0	5		2.7		2.0				4.3	
1-2	3		*3.0*		*4.5*			*4.0*	*4.0*	*3.5*
3-10	20	3.8	3.1		3.8	3.0	3.6	3.6	4.3	3.7
>10	30	3.5	3.0	3.0	3.5	3.2	3.4	3.9	4.3	3.5
All Teaching		3.7	3.0	3.0	3.6	3.1	3.5	3.8	4.3	3.5
Years Teaching AED										
0	13	4.0	3.0		3.3		3.0	4.0	4.4	3.3
1-2	2		*3.0*		*5.0*		*4.0*		*4.0*	
3-10	17	3.7	3.0		3.5	3.0	3.6	3.2	4.2	4.0
>10	21	3.5	3.0	3.0	3.7	3.3	3.3	4.0	4.3	3.6
All Teaching AED		3.7	3.0	3.0	3.7	3.1	3.4	3.7	4.3	3.7
Years Industry										
0	8		2.8		3.0		4.5		4.0	4.0
1-2	8	4.0	3.0	3.0	5.0	3.5	4.0	4.0	4.1	3.0
3-10	27	4.0	3.0	3.0	3.7	3.0	3.3	3.5	4.3	3.6
>10	12	3.0	3.0		3.4	3.0	3.0	4.5	4.3	3.5
All Industry		3.7	3.0	3.0	3.6	3.1	3.4	3.8	4.3	3.5

Table 9 - AE Design Definition ratings by years teaching, AED teaching, Industry Experience

Comment

- Note the low counts for a number of lines which make any conclusions for those lines doubtful. That is the reason those lines are gray.
- Note the considerable emphasis on *integration* and *process* for all three groupings although it varies by experience level.

By University

University	Count	Concepts	Differentiation	External Reference	Integration	Miscellaneous	Process	Products	Skills	Values
Cal Poly San Luis Obispo	8		3.0		2.5		3.0	4.0	4.5	3.5
Drexel University	8	4.0	3.2		4.0		3.0	3.5	3.8	3.5
Missouri University of Science and Technology	4		3.0		3.7		3.0		4.0	
North Carolina A&T State College	4	3.5	3.0		3.7	3.0	4.0		3.8	3.5
Penn State University	7	3.0	3.0		4.0	3.0	3.5	4.0	4.4	3.5
University of Colorado	9		3.0	3.0	4.7	3.0	3.4	3.5	4.1	3.0
University of Kansas	8		2.8	3.0	3.0	4.0	4.0		4.2	4.0
University of Nebraska - Lincoln	3		3.0		2.5			4.0	4.5	3.0
University of Wyoming	7	4.0	3.0		3.5	3.0	3.4	4.2	4.7	3.7
Combined <=3	3	4.0	3.0		4.0	3.0		3.0	4.3	4.0
Grand Total		3.7	3.0	3.0	3.6	3.1	3.4	3.8	4.2	3.5

Table 10 - AE Design definition ratings by University

Comment

- *Integration* seems to be a higher value for a group of universities: Drexel, Missouri, NCAT, Colorado.
- *Integration* is explicitly not a value for at least some individuals – note the low value for Nebraska.
- *Concepts* are important to several universities whereas they don't appear in most.
- The "Combined <=3" line represents several universities not yet interviewed with only one or two survey responses.

By Faculty Discipline

Discipline	Count	Concepts	Differentiation	External Reference	Integration	Miscellaneous	Process	Products	Skills	Values
AE	6	3.5	3.0		3.5	3.0	3.0	4.0	4.4	
Arch	5	4.0	2.7		3.3	3.0	4.0	3.0	4.3	4.0
Const Management	*3*		*3.0*		*4.0*			*4.0*	*4.0*	*3.5*
Elect Power	*3*		*3.0*		*4.5*				*4.0*	*3.0*
Environmental	5	4.0	3.0				3.0	3.5	4.0	3.5
HVAC	4	3.0	3.0	3.0	4.3	3.0	3.7	3.0	4.3	4.0
Lighting	*2*		*3.0*		*5.0*		*4.0*		*4.0*	
Structures	19		3.0		3.0	3.0	3.4	4.0	4.3	3.4
Other	13	4.0	3.1	3.0	3.6	3.3	3.2	3.8	4.3	3.7

Table 11- AE Design definition ratings by faculty discipline

Comment

- Architects, Environmentals and ”other” ranked *concepts* higher, whereas it didn’t appear for several of the other disciplines.
- *Process* was important for both Architects and HVAC faculty, and again not for others.

Sample Faculty Definitions of AE Design

To give a sense of the definitions provided by the faculty members the following definitions were selected by first arranging them in increasing length and then picking every eighth definition starting with the second.

- space allocations.
- AED is the configurational optimization of a constructed facility to meet specified needs.
- Overall it encompasses the building process as well as information on electrical, plumbing, lighting, hvac, acoustics and structural design.
- 1) The development of plans and specifications for buildings 2) Technical studies of the conceptual bases of different building designs to identify superior alternatives
- The design of engineered systems for Architecture - this does not include the integration of these systems that I beleive to be important but not the definition of AE design.
- AE Design is the Building Design aspect of AE. AE is the combination of building related engineering practices including HVAC, electrical circuits, lighting and structures as well as technical aspects of architecture design including how a building shell needs to function and building code requirements.

- Application of fundamental AE principles and analysis tools to the development of AE system. Design implies the creation of a new AE system to meet defined goals, or to help define the goals along with the system. I would like to see an AE design class include architects and engineers on the complete design of a building : structure, HVAC, plumbing, electrical, and architecture. In some cases (i.e. few students) all building systems might not be included, but this should be the goal.
- Architectural Engineering Design is the teaching of the general principles of design. Both Engineering and Architecture has underlining principles, processes and concepts that must be followed in order to create a product or object. Architectural Engineering is about designing a structure or building. The process begins with the need of the clients in the design of a building from the inside out. The client wants a building that is with in budget and works for his or her particular use. Like the human body we have the exterior covering that makes us unique and the interior of the body that is made up a skeleton(structural system) and other organs (HVAC, Electrical, Plumbing). We also have the brain which is the human that occupy and maintains the organism.

Discussion of the results for all breakdowns of the survey responses

- Potentially significant differences between the schools are noted at each table.
- The most significant agreements are on the idea of what I have called *skills* and, to a lesser extent, *products.*
- Differentiating architectural engineering design from other types of design was identified by almost every respondent in some way, but there was very little emphasis put on it. The majority of the differentiation was by use of the word *building* in the definitions.
- There appear to be significant differences about the importance of the various categories within all of the breakdowns.
- Several of the categories I created have very low response rates. It is entirely reasonable to conclude that that means the category is irrelevant. It is also possible that these identify aspects of architectural engineering design worth considering by the community.

Faculty Opinions about Their School's and National Definitions of AE Design

Immediately after the question asking respondents to give their definition of architectural engineering design they were asked if their definition agreed with that used by their school and that used nationally. The specific questions asked were:

- Is your school's definition of AED the same as yours?
- Is the national definition of AED the same as yours?

They were also given the opportunity to comment about the question. A number of them chose not to explicitly reply respond *yes* or *no*, but instead wrote comments which are sampled below in the same manner as for the definitions of AE Design. No one answered either *yes* or *no* explicitly and then wrote a comment.

Response	Count	Comments	*"Don't Know"*
Yes	20	0	
No	3	0	
Blank	27	27	7

Table 12 - Congruence of school with individual definition

Sample Comments by Faculty

- Not sure.
- I believe it is reasonably close.
- For the most part. Each faculty member varies in their definition
- To my knowledge, the Department does not have a formal definition for AED so I would be very surprised if my colleagues and I have reached consensus at this time.

Response	Count	Comments	*"Don't Know"*
Yes	10	0	
No	1	0	
Blank	35	35	21

Table 13 - Congruence of national with individual definition

Sample Comments by Faculty

- Not sure
- I don't know.
- I don't know the national definition
- I don't think there is a firm national definition (or goals) of AED, at least not clearly defined.
- 'Some what. AEI definition:" Architectural Engineering is the discipline concerned with planning, design, construction and operation of engineering systems for commercial, industrial, and institution facilities. Engineering systems include electric power, communication and control, lighting, ventilation, and air conditioning; and structural systems. An architectural engineer works closly with those in the areas of the building process to design and possibly to construct the engineering systems that make building come to life for their inhabitants"

Discussion of the results

- As might be expected there is an increasing amount of uncertainty as one progresses from school to national definitions. This is expressed in the large numbers of "don't know" responses.
- A few, but not many, identify a disagreement between their personal definition and that of their colleagues or school.

- Few if any of the respondents took a position on whether or not there should be a school or a national definition. That leaves open the question of whether a national definition is important

Disciplines Required for AE Design

In another section of the survey of faculty members were asked

> "Which of the following disciplines must be included in a course for the course to be considered as addressing AE Design - (Select all that apply)?"

They were given a choice of the following possible disciplines:

> Architecture; Structure; HVAC; Electrical; Construction Management

The results below show all possible combinations of these five disciplines. The count of those responding in some way was 35, of whom 18 made no choice specific discipline choices. 27 chose to make comments.

Discipline(s) - Required with no others	Count
Architecture (Arch)	2
Structure (Struct)	1
HVAC	0
Electrical (Elect)	0
Construction Management (CM)	0
Arch+Struct	1
Arch+HVAC	0
Arch+Elect	0
Arch+CM	0
Struct+HVAC	0
Struct+Elect	0
Struct+CM	0
HVAC+Elect	0
Elect+CM only	0

Discipline(s) - Required with no others	Count
Arch+Struct+HVAC	3
Struct+HVAC+Elect	3
HVAC+Elect +CM	0
Arch+Struct+CM	2
Arch+Struct+HVAC+Elect	6
Arch+Struct+HVAC+Elect +CM	7
Struct+HVAC+Elect+CM	0
Any Two of the above	7
Any Three of the above	4
Any two or three of the above	1
Comment but no choices	12
No Response	11

Table 14 - Discipline Combinations Deemed Required

Sample Comments by Faculty – Following the same sampling scheme

- I think any one of the above would be sufficient.
- All of the above *should* be included. Our program does not include much Electrical or CM content.
- I think that is is important to properly define AE Design, especially because we are in the business of teaching design. We should definitely know what we are teaching about. (Did not understand Question 4.)

- I understand that construction management is considered part of architectural engineering but I don't agree. Construction management is a specialized field separate from architectural engineering. The Architectural engineer and the Civil engineer must work closely with construction managers to successfully implement their designs and both AREs and CEs are well trained to become construction managers but the fields are different. Back to the question asked...I believe that discussion of a definition of AE Design is important. I am not certain that a national, consensus definition is needed but remain open to that concept.

Discussion of results

- Only two respondents believe that a single discipline is sufficient for architectural engineering design.
- Nine thought that two disciplines are sufficient, with seven of those saying "any two".
- Twelve thought that three disciplines were necessary with four of those saying "any three"
- Thirteen would like have four or five disciplines included.
- These results indicate a considerable divergence of opinions on what are the ingredients of AE design, a greater differentiation than is evident in the definitions.

Conclusions Overall

The survey results characterize faculty attitudes about Architectural Engineering Design in two ways. The more concrete is their explicit choices about which disciplines must be included in AED. There, we see a considerable variation from two up to all five of the choices provided. To some extent these probably represent the curricula of the schools, since few offer all five options, but in any case it represents a divergence that is worth discussing at the national level.

Similarly, though more disputably because the categories used are ones imposed by the author rather than chosen by the respondents, the responses to the request to define architectural engineering design diverge considerably in their inclusion and emphasis on the different categories. The disciplinary skills are near-universal in emphasis and inclusion whereas other categories are far less often included or emphasized. Again, I propose that these categories and the responses to them merit discussion at all levels.

Further Work

As the remainder of the schools complete the same survey the tables will be updated and the final results presented in June at the ASEE conference. Other questions in the survey, particularly the faculty's opinions about the major issues facing the AED profession and also the methods used to teach AED, will receive similar analysis. Finally the survey results will be compared to those derived from the interviews at the individual institutions in hopes of amplifying or contrasting what I found there with what was recorded in the survey.

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