TO: Thomas Boyd, Interim Provost
FROM: Kevin Moore, Dean CECS and Acting Division Director EDS
DATE: April 7, 2017
SUBJECT: Response to Memorandum from Senate Regarding BSE 2.0 Proposal, Dated February 15, 2017

This document is in response to the memorandum from Faculty Senate outlining questions and concerns regarding the proposed Bachelor of Science in Engineering (BSE) degree program, and is being sent to you for follow-up with Faculty Senate as you deem appropriate. Categories and questions from the Senate's memorandum are shown below in bold, with the BSE Oversight Committee's (BOC) response in non-bold font. Supporting material is attached and referenced in the body of this memorandum. It is our hope that this information will allay the Senate's concerns, illustrate the diligent and ongoing attention being applied to building this degree program, and allow the Senate to respond with a vote of approval to move forward with the degree.

Our goal is to get the Senate to re-vote this semester. With a Senate vote of approval, the BSE Oversight Committee would like to start engaging students with interest in the program and establish approved program and course specifics for inclusion in the AY18-19 Bulletin, and developing promotional material.

Concerns for prospective BSE students

- **Is there a demonstrated and well-documented demand for this degree among Mines employers?**
  We expect BSE graduate placement to go well beyond the traditional employer of Mines' graduates, and intend to purposefully expand into new avenues for graduate placement. Specific to probable placement with a "traditional" Mines employer, a high-level survey was conducted in April 2015 through the Mines Career Center's Employers Feedback survey. Although this group is typically Mines alums with probable bias towards Mines' programs, they do represent 110 employers of our graduates and cannot be dismissed on a presumption of bias. A 1-page summary of feedback is attached from those 110 responses to the employer survey.

  Furthermore, data on placement from institutions with a similar degree program was solicited:

  Response from ASU on their BSE degree program: "Part of what contributes to our graduates' success is the way we've structured the curriculum and our embedded industry partnerships. Since students have project/design experiences every semester they graduate with a resume that includes extensive experience not only with engineering fundamentals but project management, teamwork, "hands-on," and communication skills. Our capstone projects are industry sponsored so students have a lot of interaction with professional engineers and those connections also help with finding pathways to employment. It all helps." Concerning placement of the ASU BSE graduates, their 2014-2015 exit surveys shows the overall Fulton Schools of engineering 90-day employment rate was 88%, whereas for Poly Engineering (the ASU general engineering program) was 90.9%. "The main point is that the BSE graduates have equal success as other disciplinary based degrees."

  Response from CU Boulder's program (which they call "e+" – several quotations from CU's response on a general BSE included here, and others again later in this document): "Oh yes - they have many post-graduation options! They are very strong students, and have a vision for their own future. To me, they are much more the engineer of the future than is true for our more typical discipline-based engineering student. And, they are risk takers." … "Frankly, many (at least half of our 131 current e+ students) migrated into our e+ degree when they became disillusioned with their discipline-based engineering degree. Without the more design-focused, somewhat customizable e+ degree, most would have left our engineering college. That is what neither of our schools need; we need to graduate more, not fewer, engineers - and our emerging evidence is that a program like e+ contributes significantly to retention in engineering. It also differentially

attracts women (no surprise; they are our best students)." … "One huge caution: do NOT let the degree be (or appear to be) "engineering light." The status is so important to students. We have the highest transfer in- and course counting GPA requirements in the college, on par with our prestigious Aero and high-demand MCEN programs. We do not let it be a "dumping ground" for poor performing students from other engineering disciplines - this is very, very important for the identity of the students in the program, and for the program's reputation…" … "…have you considered creating a pathway through your new design-spined degree to support secondary math of science teacher licensure? I am leading the national move in this direction, and would be happy to chat with you about why engineering colleges have an opportunity to contribute to the tragic STEM teacher shortage that directly impacts our pipeline/feedstock of well-prepared engineering students. Only about 1/3 of our incoming students (and yours!) have taken physics from a teacher who has at least a minor in physics. Every engineering college has students who yearn to teach in K-12, but do not want to go through a traditional, low status school of education (for good reasons in my opinion)."

NOTE: The proposed Mines BSE has a STEM Licensure focus area option. As you can see Boulder is about to jump into the same game.

- **Employers may require a professional engineering (PE) license. A general engineering degree does not lead to professional licensure as there is no PE exam in "Engineering." Students would need to take the PE exam in ME, EE or CE to get licensed, and may have difficulty passing that as they are not sufficiently specialized in these disciplines.**
  We expect that students making a choice to be in the BSE program are doing so in the context of an entrepreneurial mindset about their future and are already comfortable taking risks in the exploration and pursuit of new realms. Though it can be argues that choosing this degree program could limit employment options relative to traditional engineering, it can also be argued that traditional engineering limits employment options relative to interdisciplinary, non-traditional fields. Furthermore, not all engineering disciplines require licensure, and not all employers specific to ME, EE or CE require licensure. In addition, any student from an ABET-accredited degree, which we expect the BSE to be, can sit for the FE exam. It's on the student to select a focus for the afternoon portion (and those with an interest in the FE can choose their electives in the degree to give them the necessary background to pass one of the afternoon portions). And, anyone who has passed the FE and has appropriate work experience can sit for the PE exam of their choice. Their degree does not matter. Nevertheless, BSE program administrators will be transparent in all regards to the degree and provide full disclosure to students during advising on employment opportunities and limitations related to licensure. Furthermore, BSE program administrators will encourage students to transfer into a discipline-specific degree if their career/ employment interests suggest a more discipline-specific path where professional engineering licensure is needed or where another degree may better serve their career interests.

- **If Mines is to create a degree for broad practitioners, then there must be a place for the students to go upon graduation. Almost all engineering graduates still need authentic work experience before becoming a project manager or group leader.**
  The BSE Oversight Committee is not suggesting graduates are qualified to go directly into project management or similar positions that typically require extensive professional experience any more so than any Mines grad is capable of such, although we believe that the four years of design experience will make BSE grads likely more capable than most new graduates in Mines' discipline-oriented degrees. The structure of the program is designed to train graduates more directly in project management, communication, and leadership skills, and for them to be potentially fast-tracked by employers into these positions. Information given for the first question in this category provides evidence that employers are seeking and hiring students with no expectations for experience with a general, accredited degree in engineering. Further, we note the comments of Jacquelyn Sullivan, one of the co-Directors of CU-Boulder's Engineering-Plus program (e+) (which was started about three years ago), who noted in an

email that the graduates from that program "… go to industry, graduate school and into K-12 STEM teaching … they have choices upon graduation, and it appears that they can do whatever they want… quit worrying about this (which we did a lot in the beginning) because our e+ students are different, and chose the more flexible, customizable degree path to suit their vision for their future - which they appear to be making their realities without any care or feeding (e.g., control) from us." She further indicated that their graduates are having no problems finding jobs. This matches anecdotal information Kevin Moore received as a ABET accreditor to the similar program at the University of Illinois.

Quality concerns

- **The Senate agrees that enhancing the reputation of Mines requires that the new program be a top-shelf product rather than a consolation degree. More detail on how this will be achieved would be helpful in light of the fact that rigor is typically associated with sacrificing breadth for depth of knowledge.**
  Rigor is tricky to articulate, and considering rigor to be "…typically associated with…" as stated above is more of an assumption of one of the ways in which rigor is defined. Depth of knowledge in any particular topic can be viewed as rigor, but it can also be viewed as "restraining" in that a topic might be learned with proverbial blinders on, thereby limiting a student's ability to see and explore the extent of how to apply new-gained knowledge in solving atypical or real-world problems. Employers sometimes attach a label of "book-smart" to the above definition of rigor, implying a lack of practical knowledge or ability to think outside the box. The BSE degree will be ABET accredited, which by the nature of that accreditation means the degree has a certain level of expected rigor. Furthermore, students with the BSE degree will have more baseline knowledge of the broad scope and potential application of engineering than most of the other engineering degrees because they will have 15 credits in the engineering foundation topics of thermodynamics, fluids, circuits, statics and materials; existing engineering degrees require only a subset of this list. [Refer to the comment from ASU on an attribute of their program, "…extensive experience not only with engineering fundamentals…"] An additional required 15 credits of traditional engineering coursework plus 6 semesters of engineering project work (the design component of the 8 Integrative Design Studios) plus potential for more engineering course work in their chosen Focus Area clearly provides substantial engineering content requirement and opportunity for selected depth, going well beyond the ABET required credits and in such a way that students will have more flexibility to tune their course of study to their interests.

  To further elaborate, the following comments were prepared for the Undergraduate Council on this topic: "Academics are notorious for believing their tribe is the best. To restate a common euphemism, "one person's rigor is another's leniency." We have heard the opinion expressed that if a student can't get past a particular course such as thermodynamics or advanced heat transfer, then that student doesn't rate. Yet we can also note evidence of C-students in such courses who excel in other advanced courses, such as PDE taught by mathematicians, or a design course in ME. Indeed, we have observed that often students may do well at purely analytical engineering sciences course but then struggle when solving complex, multi-constraint open-ended design problems involving much ambiguity. Further, when confronted with the fact that in the "real world" those ambiguities are often associated with the non-technical constraints resulting from the intersection of technology and engineering design with societal considerations, students struggle even more. It is precisely the intent of the BSE2.0 to cultivate skills that enable students to address such ambiguities in open-ended problems. Such a cultivation is every bit as rigorous as an education emphasizing advanced engineering science. Various sources on the internet define "rigor" as "…the quality of being extremely thorough, exhaustive, or accurate … demanding, difficult, or extreme conditions." Quite frankly, those of us who have been at other places find that much of Mines' reputation for "rigor" is more related to the latter sets of words than the former. It is our intention that the BSE2.0 be as rigorous as any other program on campus.

- **Student demand for the BSE at Mines is currently hypothetical – the BSE Oversight Committee should rigorously assess student demand (and employer needs) by obtaining data from existing similar high-quality programs around the U.S.**
  Mines' student interest in the BSE is not hypothetical, though actual demand cannot be determined until students specifically come to Mines for the degree who would otherwise go elsewhere for their education. An "interest" survey was conducted in December 2016, the results of which were disseminated to all departments through their Undergraduate Council representatives. Those results may not have been disseminated into the departments and therefore to the Faculty Senate reps. The 12-page student response summary is attached. Pertinent specifics include:

  - The survey went to approximately 1700 students on the CASA advisory list.
  - 260 responses (a 15% response rate, quite good for a general survey at the end of a semester).
  - 70% of the respondents are 1st year students (mainly freshmen, and some as transfer students); 25% are sophomores.
  - 39% of the respondents are enrolled in or considering Mechanical Engineering, with the rest reasonably split across the other engineering disciplines.
  - 60% are "supportive" or "very supportive" of Mines offering a BSE.
  - <20% feel that a BSE would in any way devalue the other engineering degrees.
  - Students like the stronger emphasis on professional communication skills and flexibility in the program.
  - 26% (71 students) responded with an answer of "interested" or "very interested" when asked "*Would you be interested in enrolling in this degree program knowing that the degree is not discipline specific and therefore may require more creativity and networking on your part to market yourself when first entering the job market*".

  The second part of this question/concern of employer interest/needs is addressed in a previous response.

Resource concerns

- **Given tight budgets and flat student enrollment, how is the creation of a new program justified?**
  The BSE program is not adding faculty, staff, or facilities resources in the foreseeable future, although it is a redistribution of a few existing faculty resources where the courses they typically teach will continue to be taught and are better suited for delivery through the new EDS division. A majority of the courses for the BSE degree are slated as standard courses taught by faculty from various departments through their existing course offering in their home department, for which those faculty and associated departments get recognition for teaching the course to the BSE students. The only exception for new courses is the addition of six Integrative Design Studio courses and one Communication course being offered through EDS, and these will be taught using existing faculty resources without an increase in their teaching loads as the course delivery will be a re-distribution of courses that those faculty would otherwise teach.

  The program is also justified through the potential of attracting a more diversified student base, and as Mines' overall facilities and resources can accommodate increased student enrollment the BSE becomes yet another option to attract new students. [This viewpoint is furthermore supported by comments from the CU e+ program.]

- **Who are the core faculty that will be responsible for this program and what are their backgrounds?**
  John Persichetti from CBE is transferring into EDS as Director, B.S. in Engineering degree program, and will continue teaching EPICS II and design courses until such time that the BSE degree is approved, and then move into the Integrative Design Studio sequence. John has ~20 years of industrial practice and national lab experience plus 17 FTE years at Mines at a Teaching Associate Professor level (spread over a 20-year

elapsed period). He is one of last year's recipient of the Alfred E. Jenni Fellowship award and a member of the inaugural class in Innovative Teaching and Learning, offered through the Trefny Innovative Instruction Center summer program. John will continue with the Trefny summer program as a mentor. His background is primarily in design for chemical, environmental, and biochemical processes, and has worked on projects in these industry segments, plus cryogenics, mechanical and electrical engineering systems (power, nuclear engineering, equipment design), food sciences, and on a range of government projects. He has also been one of the lead CBE Senior Design instructors for the past 9 years and taught approximately ½ of their undergraduate course offering.

Leslie Light and Jered Dean (current program directors, both with industrial and academic teaching faculty experience) are now faculty in EDS and are architecting the Integrative Design Studio sequence and how it associates with current EPICS and design courses. Their team for this course design undertaking includes Jenifer Blacklock (ME), John Persichetti, 4 full-time EPICS faculty and a variety of HASS faculty, plus touching base with other design faculty from across campus. Existing EPICS and HASS faculty, along with John, Jered and occasional other design-oriented faculty from across campus will be responsible for delivering the Integrative Design Studio courses.

John Persichetti has worked with the Director of HASS, Hussein Amery, on a variety of course design concepts, including the BSE driven Communication course and collaboration on the Integrative Design Studio sequence, and will continue to engage Jon Leydens and others currently working on a variety of communication-oriented courses.

As the financial situation at Mines turns around, and as resource allocations justify, the BSE degree in its current from is envisioned to add a couple of Teaching or T/TT faculty with demonstrated design experience.

- **If they are current Mines faculty, what will be the impact of their involvement on their current departments or divisions? Will these departments receive replacements?**
  CBE has already engaged a previous Adjunct person to come onboard full-time as Teaching Faculty to replace John Persichetti. His position is approved and contracted for a start date of July 1st. John Persichetti will continue to teach the CBE required version of EPICS II for the upcoming AY17-18, after which CBE will allow any EPIC251 course for their degree and the new hire will work on developing and delivering new courses that CBE wishes to pursue. HASS faculty that are transitioning into EDS are not leaving a gap in course delivery that requires replacement as their courses will still be taught by those faculty. Remaining faculty needed for the BSE degree are already part of the department under which the BSE will reside.

  There is no intention to "pull" faculty from an existing department without an appropriate review of the impacted department's resource needs, and provision for replacement as justified by then current and near-term department load and needs.

Impact on core curriculum

- **A thorough analysis of the impact of this new program on the core curriculum (overlap issues, changes to distributed core) is needed, possibly with input from the administration.**
  The BSE degree is expected to be overall net-neutral for student enrollment numbers over the next several years, and thus no impact on overall student numbers in the core classes. There is no change in the distributed core or engineering core – the EPICS program and HASS Division have reviewed and agreed that the sequence of E1+NHV is equivalent to Integrative Design Studio 1a/1b in terms of achieving defined Student Learning Outcomes. Likewise, EPICS and HASS have agreed that the sequence of E2+Human Systems is equivalent to Integrative Design Studio 2a/2b. This equivalence is listed in the

BSE program and bulletin description as approved by Undergraduate Council in January. The Integrative Design Studio development, ongoing by Leslie and Jered, is identifying areas where these design studios are offering richer and extended content than is typical of the existing core, thereby justifying near-term overlap and eventually removing any significant overlap of content altogether. Their work on defining a scaffolding of student learning outcomes across the 4-years of the Integrative Design Studios is discussed later in this document, with a summary as an attachment.

Other core curriculum areas are not impacted by the BSE other than possible slight shifts in enrollment numbers in select engineering courses.

- **Has the BSE committee considered adding a specific minor in this area that can apply to any engineering discipline at Mines? This may assist students in the search for project management or advisory positions with less risk vs. selecting the untested BSE major.**
  BSE characteristics that are unique relative to other engineering degree programs are: 1) allowed, yet limited, flexibility in required course selection coupled with unique/innovative career direction as captured through the Focus Area topics, 2) much stronger emphasis on design including extended "problem-based-learning" projects, and 3) enhanced emphasis on project management, communication and leadership skills. It does not seem possible to have a BSE minor that mirrors the essence of those attributes for students in a discipline-specific major. We do, however, envision eventually building a Minor in Design Theory which will likely prove to be more extensive in content requirement than being built into the Integrative Design Studios which have a stronger emphasis in design practice. Likewise, the possibility exists for the EDS Division to build a Minor in Project Management, but that has not been explored in any serious manner. Some of the Focus Areas, too, will likely prove to be good options for an ASI in their current form. Overall, we cannot envision a scaffolding approaching to building up the BSE from a couple of minors or series of ASIs. A barrier for students to pursue a minor is the necessary added content that may not fit into a student's free electives, thereby extending their time to graduation. The BSE curricular makeup allows these course pursuits to be part of their core degree curriculum. Other departments can certainly put forward minors and ASIs, and some have, with parallels to the BSE Focus Areas. The BSE bulletin wording states (page 9):

  > Students will be restricted from selecting a Focus Area and receiving a similar minor at the same time. For example, students may not take the Energy Focus Area and receive the interdisciplinary Energy Minor. Similarly, Focus Areas will not be included in the BSE degree curriculum if they are too similar to an existing bachelor's degree at Mines. For instance, a Focus Area in Electrical Engineering would not be allowed, given that Mines offers a Bachelor of Science degree in Electrical Engineering.

<u>Errors and omissions in the current proposal</u>

- **UGC representatives noted errors in the curriculum development that could have been prevented by building the degree with a full determination and presentation of things from the ground up: courses, bulletin information, flowchart/calendar structure, and finally the degree change on the whole.**
  Respectfully, the committee developing the degree in fact spent the better part of a year on this proposal, doing it very much from the ground up. An initial outline of the degree was developed in August 2015 as part of the output of a Strategic Planning Working Group. That outline was discussed with many constituents over the next 9 months and turned into a draft bulletin copy over the summer of 2016. Then the BSE bulletin description was first presented to Undergraduate Council in October, 2016, and revisited at each meeting through January, 2017, after which it was approved by that Senate subcommittee. The initial presentation was informational for UGC members to take back to their departments for discussion and feedback, and included much of the information outlined above, including a high-level flowchart/calendar structure. That initial presentation included extensive catalog descriptions for the seven new courses that were more inclusive than eventually intended. At the November meeting, the

revised BSE bulletin description included revised catalog descriptions of the seven new courses. Details for those seven new courses were also submitted through CIM and presented to Undergraduate Council, each separate submission including: justification for the new course, catalog description, student learning outcomes, prerequisite requirements, an overview description of laboratory and special exercises, and an impact statement on other programs. These submissions did not include specifics for "assessment methods" and "pedagogical strategies to support student learning", but discussion establishing those specifics were already being held with the Trefny Innovative Instruction Center, and those discussions were conveyed in the CIM documents and to the Undergraduate Council. The November course submissions also did not include a syllabus for each course giving topic name, topic outline and hours.

The committee recognizes that syllabi and assessment still need to be determined before courses can be offered, and since these courses are not in the AY17-18 Bulletin they cannot be offered in the upcoming academic year except as special topics. The scaffolding of topics and learning outcomes for the Integrative Design Studio sequence, developed by Leslie Light and Jered Dean, will result in significant syllabi details. A working copy of this effort is included as an attachment herein, and is expected to undergo continued refinement throughout summer with portions of content and assessment planned to be piloted throughout AY17-18 in traditional EPICS and capstone design courses. This representation of the BSE Integrative Design Studio sequence into capstone design captures specific learning outcomes throughout the 4-years in high-level categories of: Design; Teaming / Project Management; Hands-on Skills / Safety; Incoming Communication; Outgoing Communication; Impact / Ethics / Social Justice; and Logical / Critical Thinking. Each learning outcome is tagged with (I), (R), or (P) to represent the outcome, and its assessment approach, as Introduce, Reinforce, or Proficient as it scaffolds through each year. Furthermore, color coding is used to show how the BSE Integrative Design Studio learning outcomes are aligned with current learning outcomes for EPICS I, EPICS II, NHV, and Human Systems; BSE learning outcomes in the first two years shown in black font are extended, richer content which is expected to expand as the courses mature. At this time, a few learning outcomes from NHV and Human Systems still need to be rolled into the learning outcomes map for the BSE Integrative Design Studios. We are actively working with HASS on how to capture that existing course content into the BSE design studio content. These omissions are also shown in the attachment. Lastly, a full syllabus and assessment methods need to be worked out in cooperation with HASS for the Communication course. The committee intends a complete resubmission of each of the seven courses in the next review/approval cycle for UGC.

The BOC is also working cooperatively with the Registrar's Office (specifically Lara Medley), which provided notes on the "BS-Engineering degree proposal", identifying discrepancies and potential areas of confusion by students that should be clarified in the final catalog copy. Those comments are being addressed, which for the most part are accomplished through wording changes to clarify how prerequisites or learning outcomes are interpreted and handled (the BSE is not waiving or altering any course prerequisites or learning outcomes for existing courses), sequencing of courses, allowed flexibility for when to take a course, etc. The BSE Director initiated and continues to work on a detailed flowchart of all courses listed in the BSE bulletin description, to eventually be built into a format that guides advisors and students on possible sequencing and noting potential problem areas.

An area of discrepancy noted by the Registrar's Office is variability in credit hour requirements for the different Focus Areas. Further along this line, the BSE Oversight Committee is reviewing each Focus Area to provide additional context and curricular design to make them more enticing to students' innovative interests and, across the board, ensure each Focus Area be limited to 18-20 credit hours of required course work with any exceptions to this being explicitly and clearly noted in the Bulletin description and through direct student advising.

- **Specification of learning objectives, assessment methods, and outcomes for new courses (and existing courses that will be used with new programmatic goals) should be fully determined.**
  A partial response to this concern is addressed in the above. Ideally, other departments should not adjust outcomes for their existing courses in order to accommodate perceived programmatic goals for the BSE.

The intent of the BSE is for students to learn topic-specific material in the context of how that material is used in its associated discipline. Departments should only alter course objectives to the extent that changes make sense in serving the changing needs of the profession and students enrolled in that discipline-specific course of study.

As a final comment, the BOC is also actively working on an ABET continuous improvement process (CIP) for the BSE that we intend to be an exemplar on the campus, so that the initial and continuing ABET accreditation visits will be seamless. We intend that CIP is a core value of this program.

Attachments:

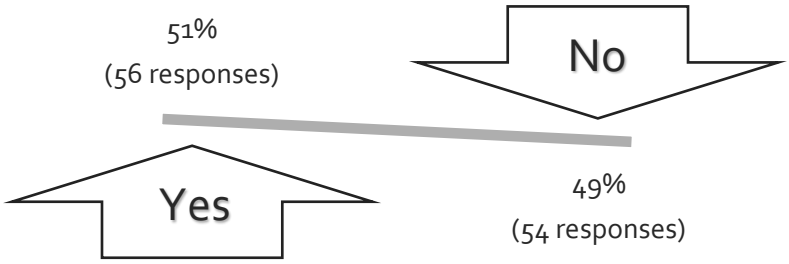
1	page	BS Engineering Degree Demand
12	pages	B.S. in Engineering Student Survey Results
2	pages	BSE DESIGN STUDIO LEARNING OUTCOME FRAMEWORK

BS ENGINEERING DEGREE DEMAND

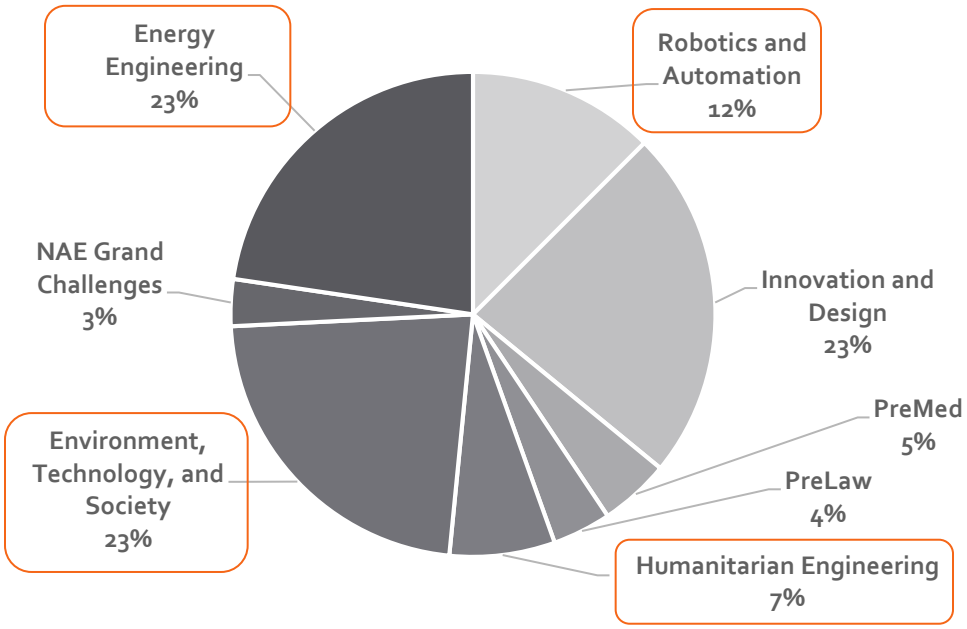
EMPLOYERS ARE INTERESTED

In April 2015, two questions regarding the desirability of BSE degreed students were embedded in the CSM Employer Feedback survey administered by the Career Center. Of the 110 responses received, approximately half of respondents said they would be interested in hiring students with a general engineering degree.

Q14: Would your company or organization be interested in students with a "general" BS in Engineering degree?



Q15: If yes, which of the following secondary fields would be of interest to your organization?



Note that boxed topics are explicitly tied to proposed BSE Focus Areas, with Innovation and Design (at 23%) as a foundation of the entire BSE Program!

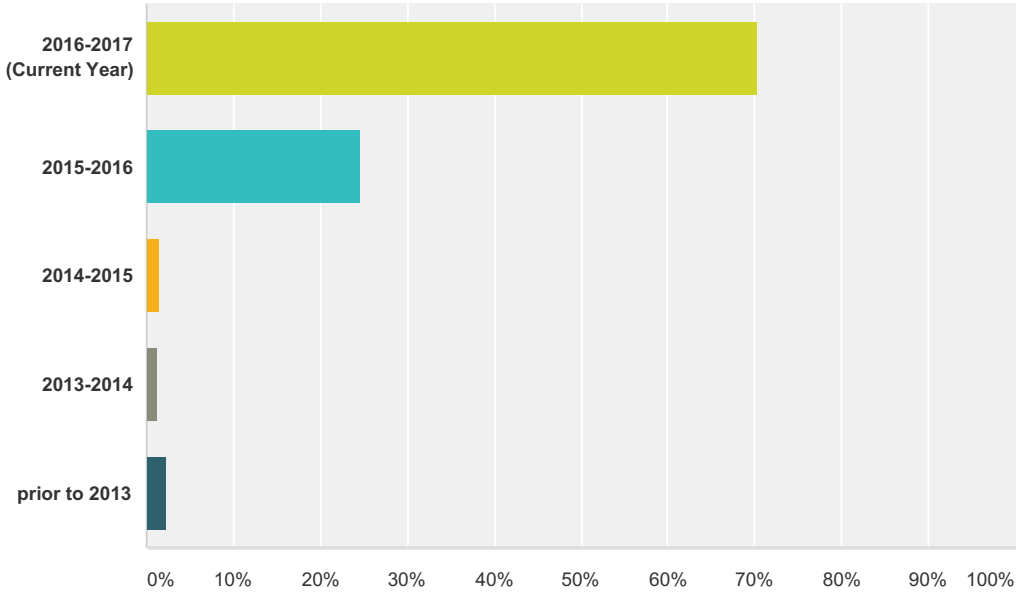
In May 2013, ASEE with support from NSF launched a series of workshops called "Transforming Undergraduate Education in Engineering." Seven academics and 26 reps from industry offered their opinions on the key knowledge, skills, and abilities that 21st century engineering graduates should possess. While Science came in highest, systems engineering was nearly as highly rated at 53% of respondents. However, only 23% of respondents felt engineering programs were handling it well (ASEE, 2013). Addressing this is one of the key goals of the BSE.

PEER INSTITUTIONS WITH SUCCESSFUL BSE PROGRAMS OF EXCELLENCE

CU Boulder	**Olin College**	**Harvey Mudd College**
Michigan Tech	**University of Illinois**	**Lehigh University**
Temple College	**ASU**	**Johns Hopkins University**

Q1 In what year did you start at Mines?

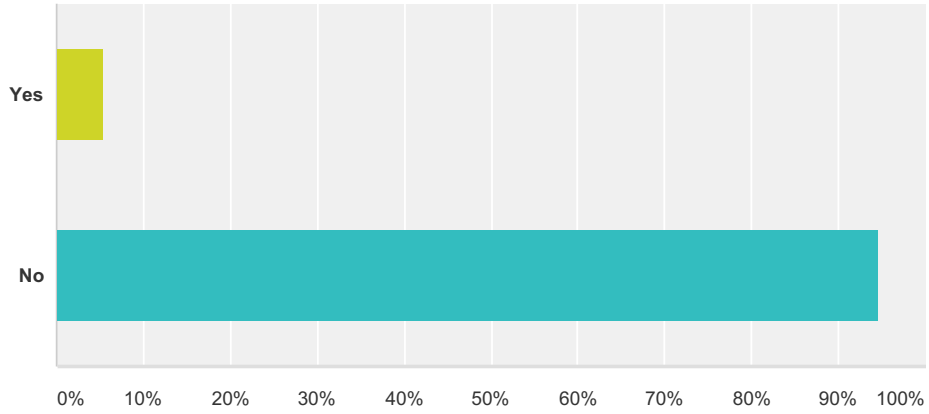
Answered: 260 Skipped: 0



Answer Choices	Responses	
2016-2017 (Current Year)	**70.38%**	183
2015-2016	**24.62%**	64
2014-2015	**1.54%**	4
2013-2014	**1.15%**	3
prior to 2013	**2.31%**	6
Total		**260**

Q2 Did you start as a Transfer student?

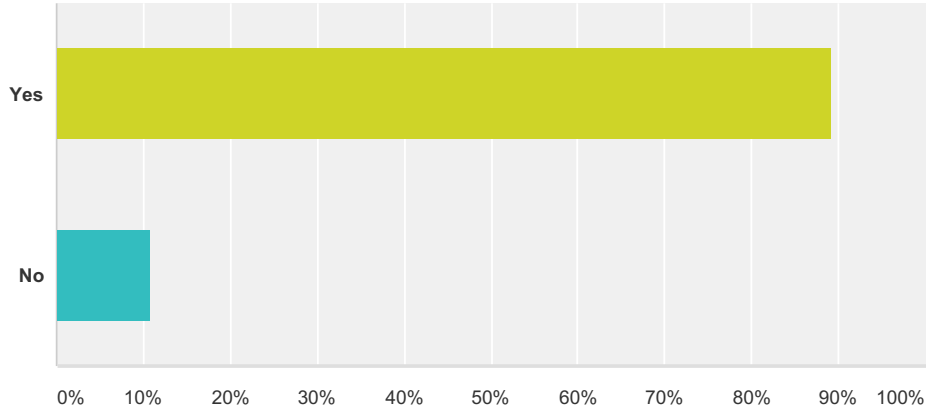
Answered: 260 Skipped: 0



Answer Choices	Responses	
Yes	**5.38%**	14
No	**94.62%**	246
Total		**260**

Q3 Are you currently enrolled in or strongly considering enrolling in one of the traditional engineering degree programs (e.g. Petroleum, Mining, Mechanical, Chemical, Electrical, Civil, Environmental Engineering)?

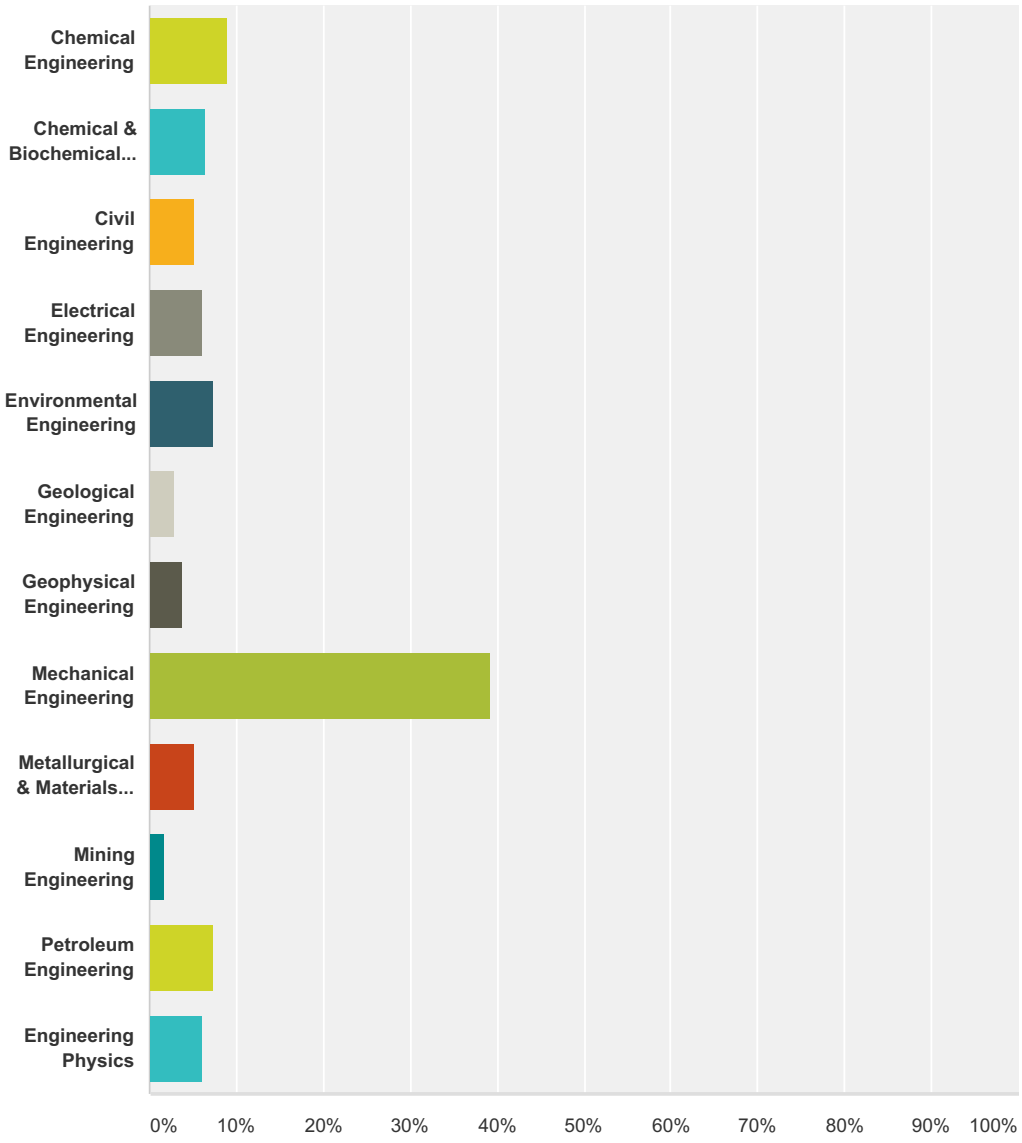
Answered: 260 Skipped: 0



Answer Choices	Responses	
Yes	**89.23%**	232
No	**10.77%**	28
Total		**260**

Q4 If you answered Yes, which specific engineering degree program?

Answered: 234 Skipped: 26

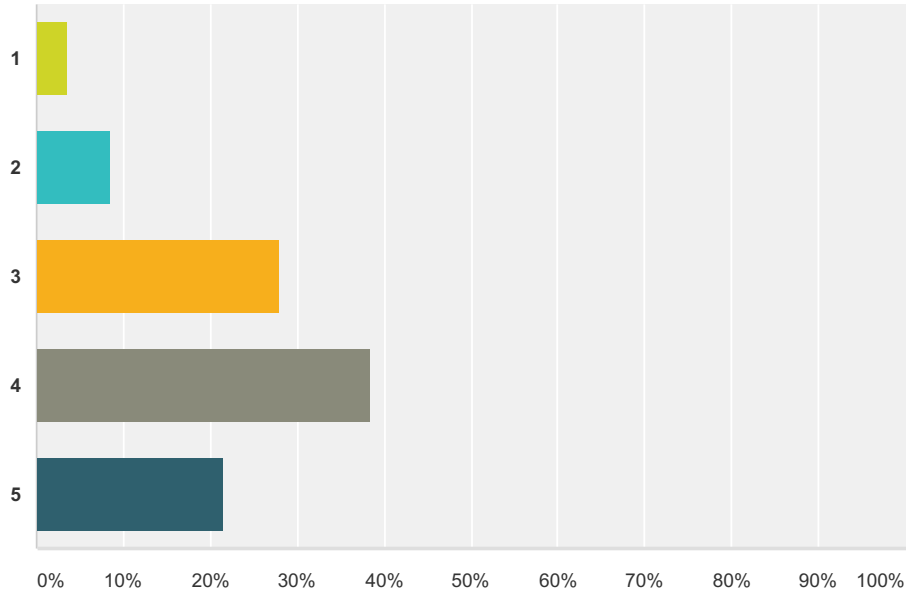


Answer Choices	Responses	
Chemical Engineering	**8.97%**	21
Chemical & Biochemical Engineering	**6.41%**	15
Civil Engineering	**5.13%**	12
Electrical Engineering	**5.98%**	14
Environmental Engineering	**7.26%**	17
Geological Engineering	**2.99%**	7
Geophysical Engineering	**3.85%**	9

Mechanical Engineering	**39.32%**	92
Metallurgical & Materials Engineering	**5.13%**	12
Mining Engineering	**1.71%**	4
Petroleum Engineering	**7.26%**	17
Engineering Physics	**5.98%**	14
Total		**234**

Q5 Rank your preference for Mines to offer the Bachelor of Science in Engineering Degree as briefly outlined in the opening paragraphs (1 = opposed; 3= indifferent; 5= very supportive).

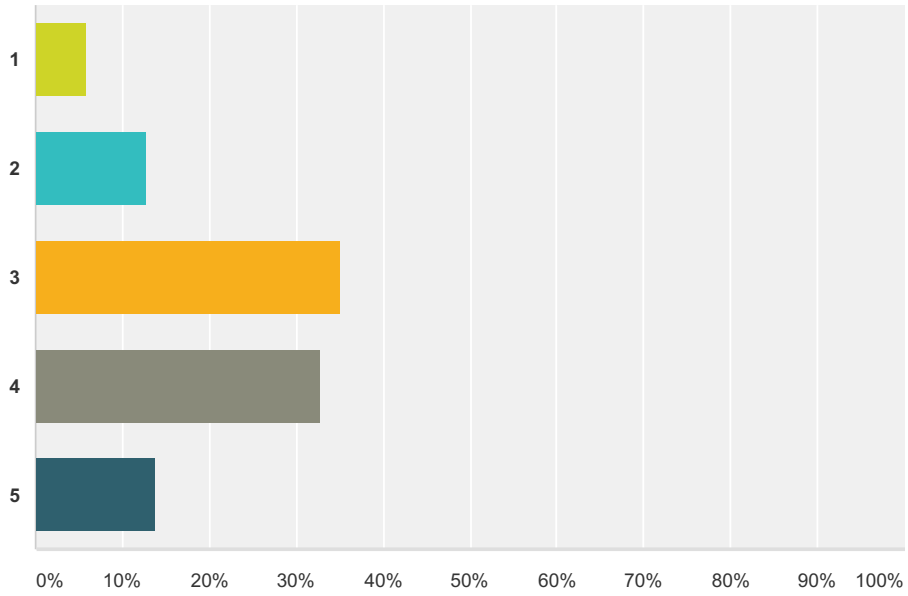
Answered: 260 Skipped: 0



Answer Choices	Responses	
1	**3.46%**	9
2	**8.46%**	22
3	**28.08%**	73
4	**38.46%**	100
5	**21.54%**	56
Total		**260**

Q6 Rank your opinion as to the impact the BSE degree (as outlined above) might have on the “value” of our existing engineering education offered at Mines (1= decrease the value of other degrees/institution; 3= will not add to or subtract from the value; 5= enhance the value of other degrees/institution).

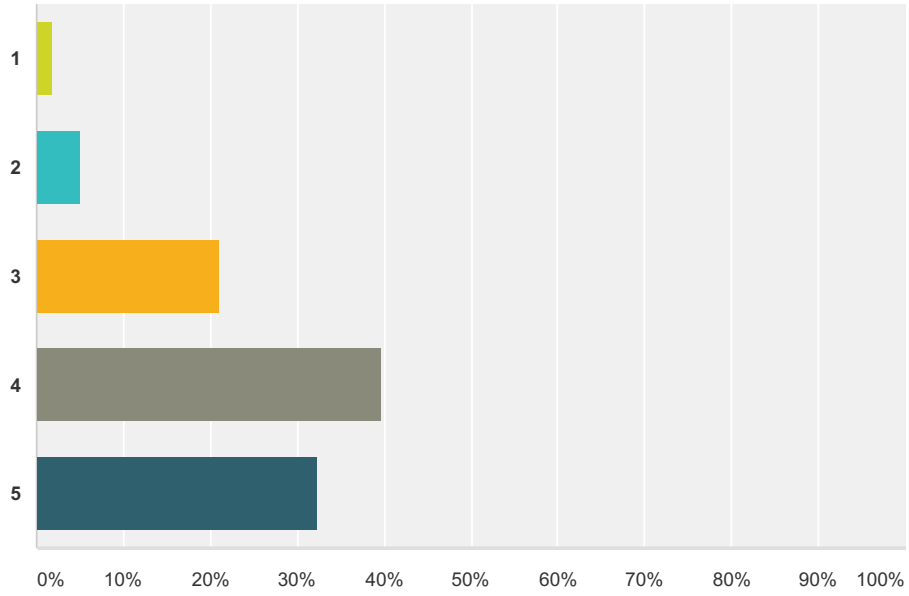
Answered: 260 Skipped: 0



Answer Choices	Responses	
1	**5.77%**	15
2	**12.69%**	33
3	**35.00%**	91
4	**32.69%**	85
5	**13.85%**	36
Total		**260**

Q7 Rank your views on the following statement: It is important that Mines offer an engineering degree program with greater emphasis on professional practice skills such as increased communication skills and direct connection to solving real-world problems (1= strongly disagree with statement; 3 = neutral; 5= strongly agree with statement).

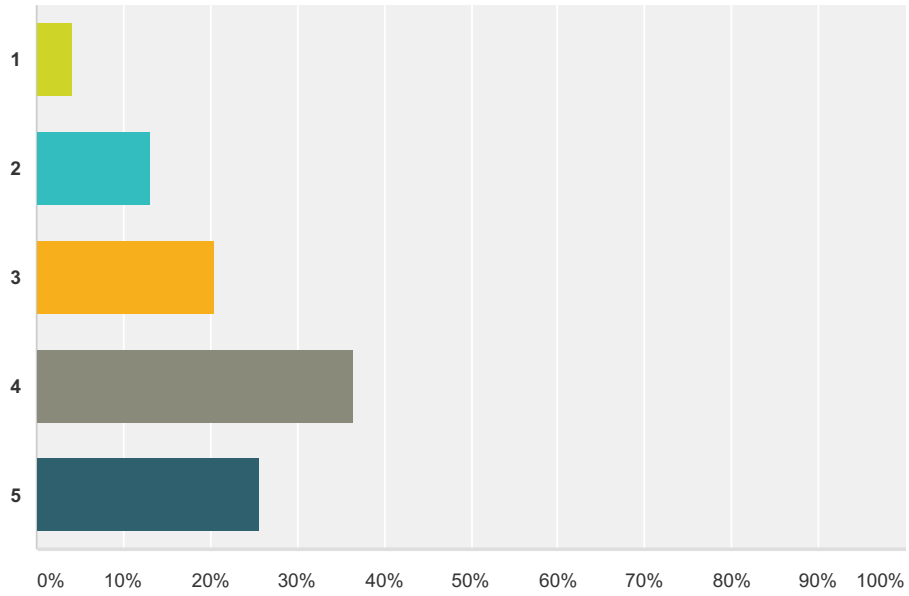
Answered: 260 Skipped: 0



Answer Choices	Responses	
1	**1.92%**	5
2	**5.00%**	13
3	**21.15%**	55
4	**39.62%**	103
5	**32.31%**	84
Total		**260**

Q8 Rank your views on the following statement: It is important that Mines offer an engineering degree program that allows greater flexibility for students to customize their studies and earn the degree with fewer credit hours (1= strongly disagree with statement; 3 = neutral; 5= strongly agree with statement).

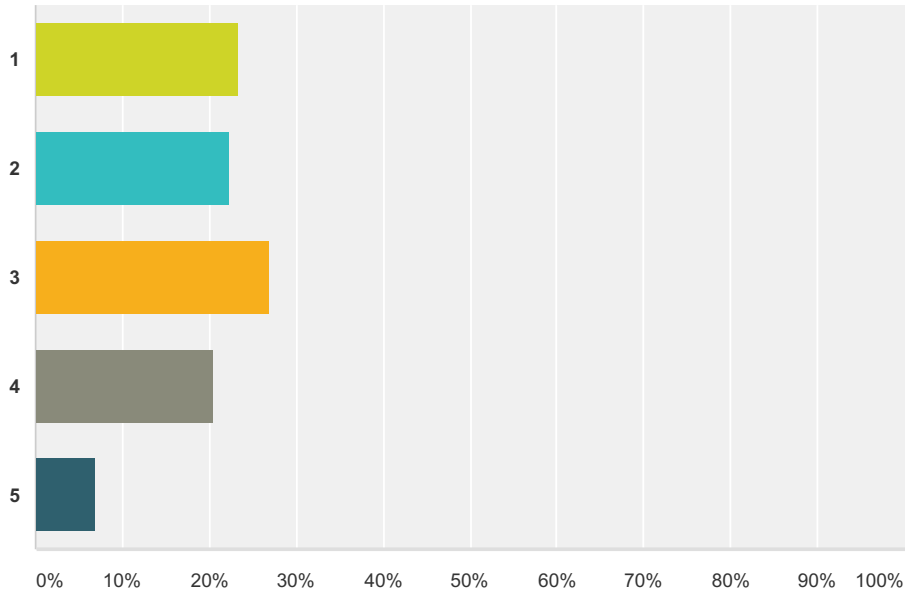
Answered: 260 Skipped: 0



Answer Choices	Responses	
1	**4.23%**	11
2	**13.08%**	34
3	**20.38%**	53
4	**36.54%**	95
5	**25.77%**	67
Total		**260**

Q9 Would you be interested in enrolling in this degree program knowing that the degree is not discipline specific and therefore may require more creativity and networking on your part to market yourself when first entering the job market (1= not interested at all; 3 = indifferent; 5 = very interested)?

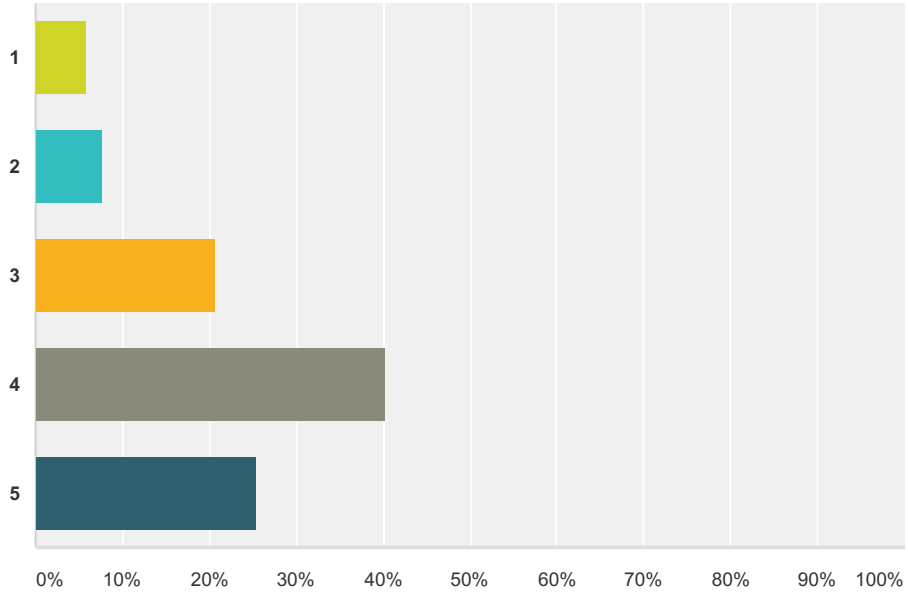
Answered: 260 Skipped: 0



Answer Choices	Responses	
1	**23.46%**	61
2	**22.31%**	58
3	**26.92%**	70
4	**20.38%**	53
5	**6.92%**	18
Total		**260**

Q10 On a scale of 1 to 5, with 1 being “no, not at all” and 5 being “yes, absolutely”, what recommendation do you make to the university administration in deciding to go forward with the BSE degree, regardless of your personal interest in the degree?

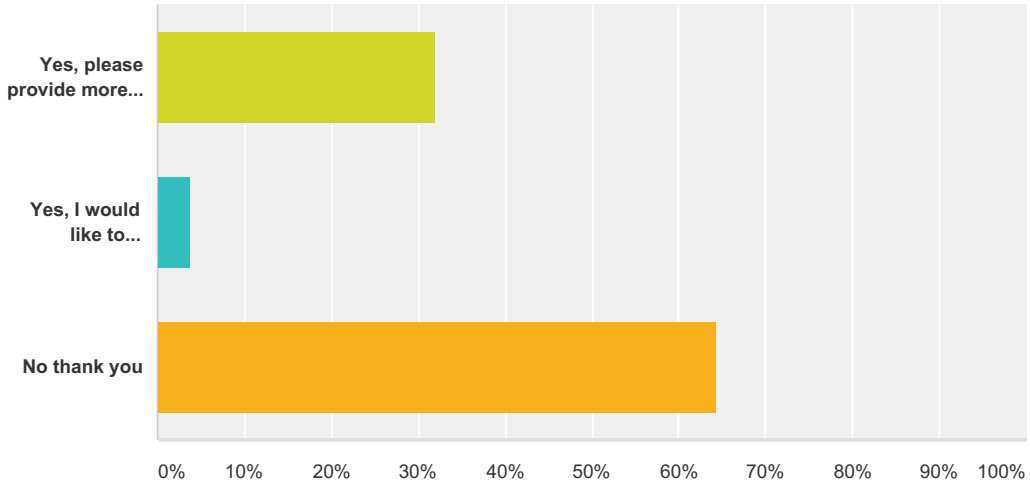
Answered: 260 Skipped: 0



Answer Choices	Responses	
1	**5.77%**	15
2	**7.69%**	20
3	**20.77%**	54
4	**40.38%**	105
5	**25.38%**	66
Total		**260**

Q11 Would you like more information as the degree is developed, or to participate in shaping this degree?

Answered: 260 Skipped: 0



Answer Choices	Responses	
Yes, please provide more information as it is developed	**31.92%**	83
Yes, I would like to participate in shaping this degree	**3.85%**	10
No thank you	**64.23%**	167
Total		**260**

I - Introduce
R - Reinforce
P- Proficient

BSE DESIGN STUDIO LEARNING OUTCOME FRAMEWORK

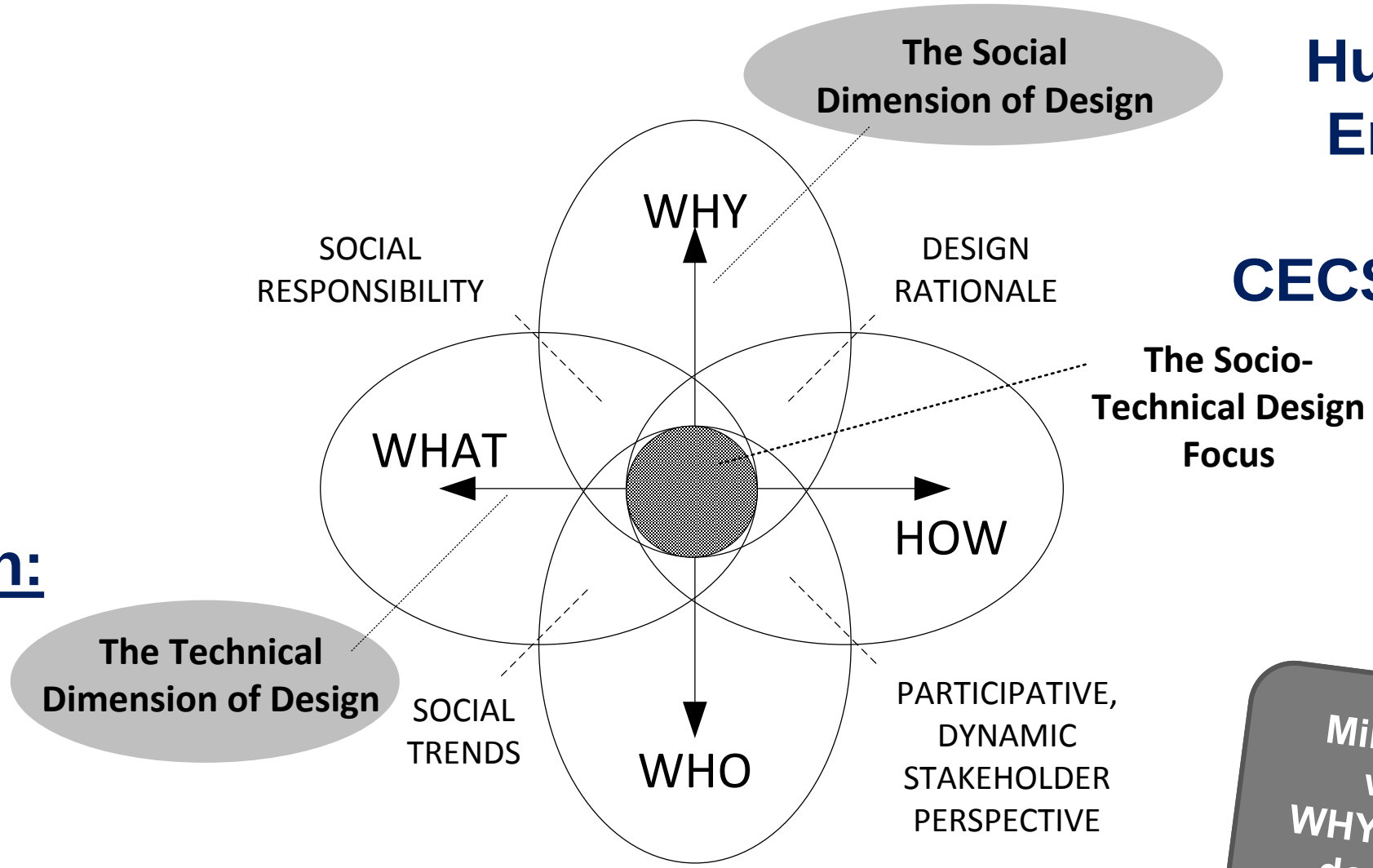
EPICS I
EPICS II
NHV
Human Systems

	Year 1	Year 2	Year 3	Year 4	
Design	**4 phases of Design: Problem Definition - Exploration - Analysis - Implementation**				
	(I) Divergent problem solving, idea generation, and iteration **(I) Conceptual design and focusing** **(I) User validation of proposed solutions** **(I) Risk analysis and mitigation**	**(I) Problem definition** **(R) Divergent problem solving, idea generation, and iteration** (I) Design critique and concept evaluation **(R) Risk analysis and mitigation**	(I) Engineering design process (I) Convergent problem solving, focused on technical verification (R) Risk analysis and mitigation (I) System integration	(P) Divergent + Convergent (I) System level design and verification	
Teaming / Project Management	**Good coordination, effective breakdown of tasks, accountability, 5 dysfunctions of a team, civil discourse, no artificial harmony**				
	(I) Developing a WBS **(I) Holding team accountable to a project plan (who does what by when)** **(I) Dividing tasks effectively** **(I) Coordinating with a single manager**	**(I) Project schedule incorporates dependencies,** and evidence **(I) Managing a client** **(R) increased complexity of tasks with less supervision**	(I) Managing testing (R) Documentation and project plan updates based on evidence (pre-plan for risk and subcontracting)	(R) Managing testing (P) Documentation and project plan updates based on evidence (I) Coordination of multiple plans, possible sub-contracting	
Hands-on skills/Safety	**Turn a wrench, know how equipment sounds and feels, choose right tool for the job**				
	(I) Low precision prototyping (foam, cardboard, wood, PVC) **(I) Cut & assemble** **(I) Woodshop certification**	(I) Digital protoyping **(I) 3D printing + plastics** **(I) Electronics prototyping** (I) Machine shop certification **(R) Prior hands-on skills**	(I) General testing equipment and calibration (R) Prior hands-on skills	(I) Specialized equipment needed for focus area (R) Prior hands-on skills	
Incoming Communication	**For: Written, Oral, Graphics, and Demonstrations**				
	(I) Conduct and synthesize expert and user interviews **(I) Receive, weigh, and synthesize feedback and arguments and incorporate in design** **(I) Conduct design research using scholarly and authoritative sources** **(I) Maintain a design notebook** **(I) Listening**	(I) Conduct and synthesize user observations; **(R) Receive, weigh, and synthesize feedback and arguments and incorporate in design**	(I) Reading and utilizing technical drawings and specification sheets; (R) Receive, weigh, and synthesize feedback and arguments and incorporate in design	(I) Read emotions, body language, social dynamics and use as input in design (learn to read what people are not saying) (P) Receive, weigh, and synthesize feedback and arguments and incorporate in design	
Outgoing Communication	**For: Written, Oral, Graphics, and Demonstrations Includes Rhetoric**				
	(I) Pitch presentation, tradeshow presentation, prototype demo **(I) Technical and pursuasive writing through a process of drafting and revision** **(I) Graphics: conceptualization, visualization, sketching, CAD** **(I) Rhetoric: Audience, Style**	**(R) Same presentations and demos, less supervision.** **(I) Proof of concept demonstration.** **(R) Technical and pursuasive writing** **(R) Graphics** (I) Aesthetics of presentation (graphs, colors, figures, feel, tone)	(I) Articulate your work and its importance to non-experts; (R) Aesthetics of presentation (P) Proof of concept demonstrations	(R) Articulate importance of work to non-experts; (P) Aesthetics of presentation (P) Presentations and demonstrations (P) Technical and persuasive writing	
Impact /Ethics / Social Justice	**Building and ethical compass and actively engineering for social justice**				
	(I) User empathy and need-finding (I) Identifying structual conditions that impact individual actions **(I) Contextual listening** (understanding how to ask questions and listen to people's struggles, desires, fears about why they came to ask for a design solution); **recognize the interconnected social and technical dimensions of a design challenge**	**(R) User empathy, needs assessment and social values analysis** **(I) indentify major frameworks for considering environmental ethics** (I) Propose ways that engineers might increase opportunities and available resources in practice; (R) Contextual listening; **(I) Acknowledge political agency of designer and user;** **(I) Learn how engineering design can increase/decrease opportunities, resources, risks/harms of stakeholders**	(I) apply a professional code ethics as a tool to analyze or more cases (R) Propose ways that engineers can acknowledge the political agency of the communities that they work with; (R) Contextual listening; (R) Acknowledging political agency of designer and user; (R) Learn how engineering design can increase/decrese opportunities, resources, risks/harms of stakeholders	(R) Propose concrete ways that engineers can increase human capabilities and provide examples of times when engineers have decreased human capabilities; (P) contextual listening; (R) learn how engineering design can increase/decrese opportunities, resources, risks/harms of stakeholders	
Logic / Critical Thinking	**Analysis (breaking down into parts, logical fallacies, interpretation), Summary, Synthesis, Evaluation**				
	(I) Examining biases and logic **(I) Analyzing an argument, evaluating alternatives** **(I) Multiple alternatives and perspectives as beneficial to problem-solving**	**(I) Interpreting conflicting, complex and/or ambiguous data** **(I) Summarizing complex/conflicting data** **(R) Multiple alternatives** and perspectives as beneficial to problem-solving (R) Analyzing an argument, **evaluating alternatives** (I) Making judgments	(I) Synthesizing a strong argument; effectively use evidence to back up argument (R) Making judgments	(P) Multiple alternatives and perspectives as beneficial to problem-solving (P) Making judgments	
Missing for NHV?					
	Critical reading skills				
	identifying arguments?				
Human Systems:	Demonstrate knowledge of the historical development of cultural, social, political, and economic systems int he odern era		Topics covered include development patterns in key regions of the world; the causes and outcomes of globalization; and the influence of energy, technology, and resources on development.		
	Draw informed comparisons between different socieities and courses of social development				

	Demonstrate critical awareness of contemporary social systems and institutions and the implications of life and work within a globalized world			
	Critically anlyze and construct effective, well-organized arguments on issues related to himan systems, socio-economic devleopment, and globalization			

WHY BSE?

Strength:
Mines



Strength:
Humanitarian Engineering, EPICS, CECS Capstone

Mines students want *more* WHY-WHO and so does industry.

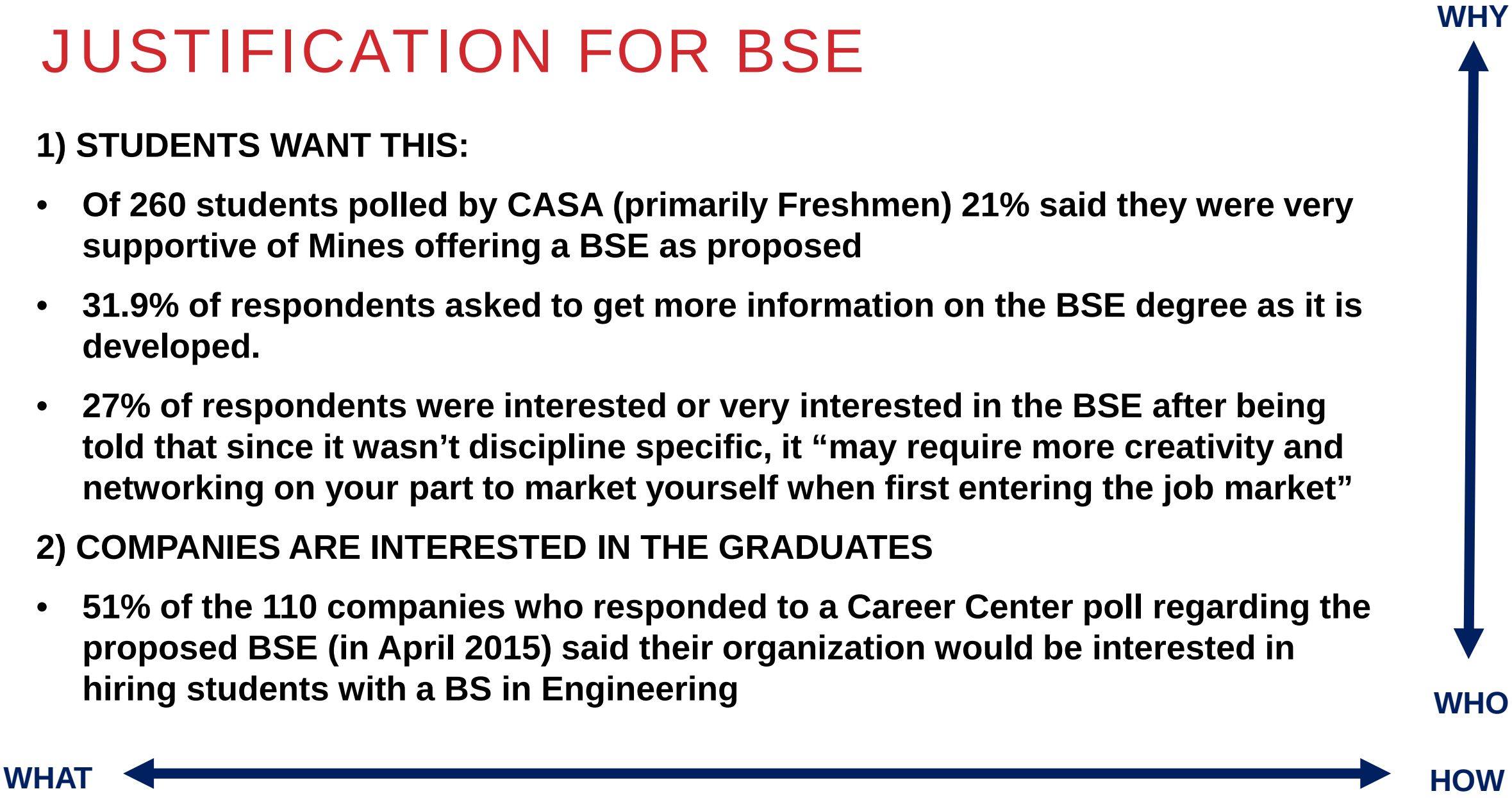
JUSTIFICATION FOR BSE

1) STUDENTS WANT THIS:

- **Of 260 students polled by CASA (primarily Freshmen) 21% said they were very supportive of Mines offering a BSE as proposed**
- **31.9% of respondents asked to get more information on the BSE degree as it is developed.**
- **27% of respondents were interested or very interested in the BSE after being told that since it wasn't discipline specific, it "may require more creativity and networking on your part to market yourself when first entering the job market"**

2) COMPANIES ARE INTERESTED IN THE GRADUATES

- **51% of the 110 companies who responded to a Career Center poll regarding the proposed BSE (in April 2015) said their organization would be interested in hiring students with a BS in Engineering**



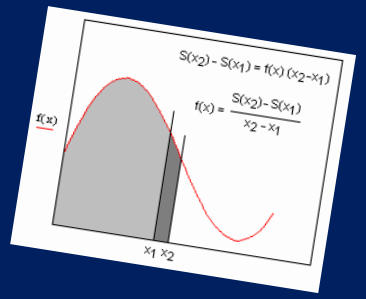
YEAR 1

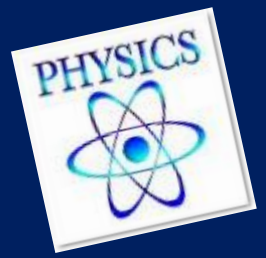
DESIGN STUDIO 1A&B

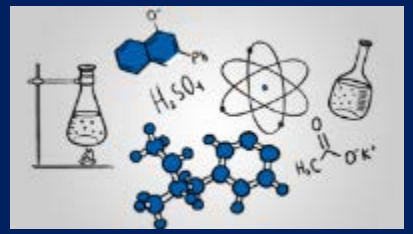
WHAT ⟷ HOW

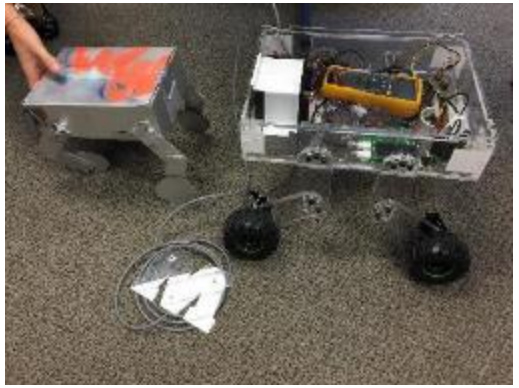
WHY ↕ WHO

- Calc I & II
- Chem I
- Physics I
- Communication









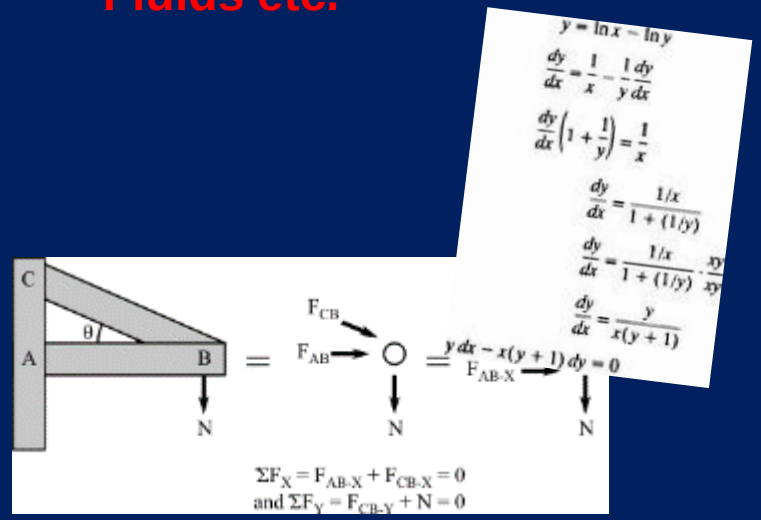
Generate & select ideas, iterate	Gantt chart, Group work	Lo-res prototyping	Listen, interview	Present, write, sketch	Need finding, contexts	Biases, analyses, alternatives

YEAR 2

DESIGN STUDIO 2A&B

WHAT ⟷ HOW

- Calc III
- Differential EQ
- Physics II
- HASS Elective
- + 12 hrs Engineering Courses like Statics, Thermo, Materials, Fluids etc.



WHY

WHO

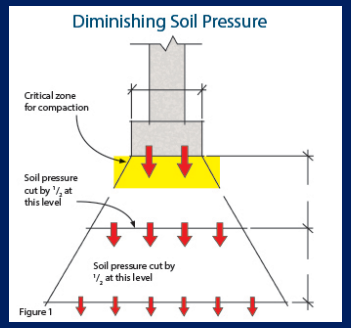
Define problem, subsystems	Manage client, critical path	Hi-res prototyping	Observe, synthesize	Present, write, sketch, demo	Ethics, opportunities	Conflicting data, making judgments

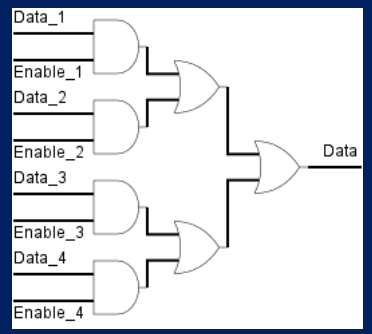
YEAR 3 DESIGN STUDIO 3A&B

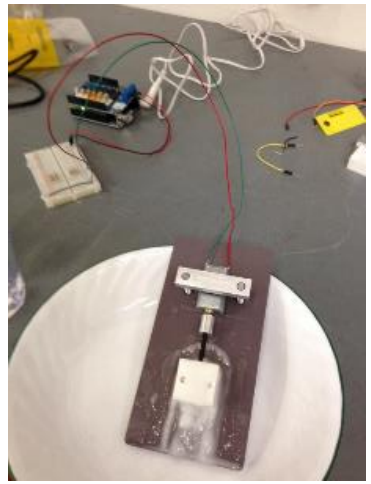
WHAT ⟷ HOW

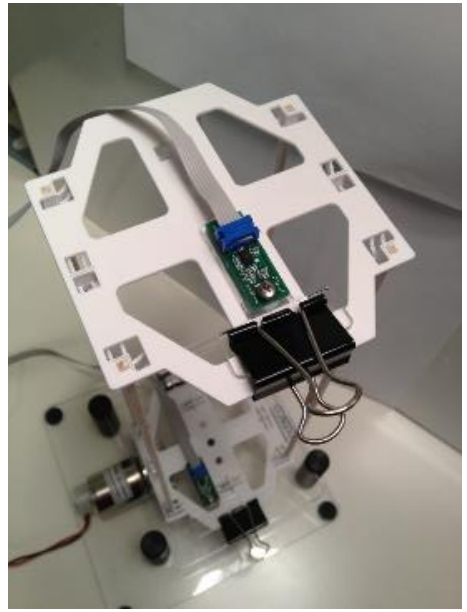
WHY ↕ WHO

- Distributed Science Course
- Principles of Econ
- 9 hrs of Focus Area Courses
- + 15 hrs Engineering Courses like Heat Transfer, Soil Mechanics, Digital Logic, Etc.









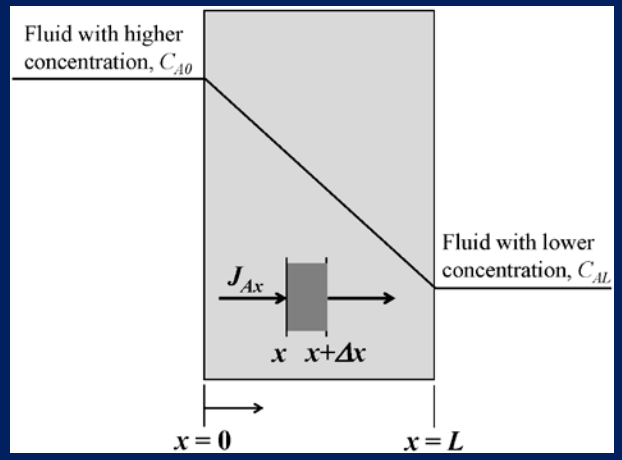
Design Process	Manage Testing	Prototype to Test	Use Technical Inputs	Articulate Complex Work	Professional Ethics	Making Strong Arguments

YEAR 4

SENIOR DESIGN I/II

WHAT ⟷ HOW

- 6 hrs HASS Credits
- Another Engineering Elective Course like Fluids II
- 12 hrs of Focus Area Coursework



WHY ↕ WHO

System Design	Coordinate Multiple plans	Use Specialized Equipment	What Aren't People Saying	Technical Persuasive Writing	Increase Human Capabilities	Making Judgements