Topical Concerns and Critical Questions Engineering Students Want/Need Answers To: Dependence on Key Groups

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***Abstract* —** This Research to Practice Full Paper examines which topical concerns and critical questions engineering students want/need answers to – based on a survey associated with a list of 201 critical questions (addressing 17 topics) asked by students since 2001. Over this period, the lead author has run an *Academic Success and Professional Development (ASAP)* mentoring-scholarship program (supported by NSF/industrial funding) aimed at recruiting, training, graduating and placing engineering students. This project-centric program at Arizona State University (ASU) – and the associated community of practice (consisting of learners and faculty-industry-peer mentors), while currently focusing on upper-division transfer students, serves upper-division non-transfers and some graduate students. The list of topics and questions was created to help students ask questions and think about the opportunities/challenges before them. Data for the most recent cohort of 74 scholars is presented and analyzed. It is shown how the list of selected critical topics and questions varies depends on gender, minority status and age. Analysis of the data shows that higher-risk (higher-context) groups (e.g. women, underrepresented minorities) focus more on shorter-term career goals while lower-risk groups focus more on longer-term career and life-planning goals. The information presented should be helpful to program leaders, administrators and educators advising engineering students.

***Keywords* —** *academic success, professional development, career-shaping projects, mentoring, scholarships, transfer students, context diversity*

I. Introduction and Motivation

In this section, we provide a brief description of our time-tested student-centered mentor-assisted engineering (*ENG) Academic Success and Professional Development (ASAP)* mentoring-scholarship project-centric program. Here, ENG stands for engineering and represents all traditional engineering disciplines (i.e. aerospace, biomedical, chemical, civil and environmental, computer systems, electrical, industrial, materials, mechanical), including computer science and engineering management. Additional program details are presented in the two FIE2018 papers [1,2]. **Overview: Background & Problem Being Addressed.** This paper, as well as our other two FIE 2018 papers [1,2], is motivated by the need to recruit, retain, empower, train, graduate and place engineering students in the engineering in order to meet national needs [17,18]. To address this need, we have developed a student-and-project-centric ENG *Academic Success and Professional Development (ASAP)* mentoring-scholarship program that has been funded by the National Science Foundation (NSF) since 2001. Fundamental to the program is that all scholars must participate in career-shaping/steering projects [1,2]. While currently focusing on upper-division community college (CC) transfer students, the program also serves upper-division non-transfers and some graduate students (that started as undergraduates in our program). While 9 Arizona CCs are part of the current $5M (ASU share: $4M), 5-year, 10 institution NSF-funded grant (Central Arizona, Eastern Arizona, Cochise, Estrella Mountain, Glendale, Mesa, Phoenix, Mohave, and Yavapai), the program serves many other CCs across the region. This paper, as well as our other two 2018 FIE papers [1,2], describes work taking place at the lead (4-year) institution – Arizona State University (ASU). Future papers will describe similar activities taking place at partnering CCs. The program combines an *ENG ASAP Transfer Excellence Academy* framework – like an honor's college, but more focused on professional development – with an active community of learners and faculty-industry-peer mentors forming a vibrant community of practice [19,20]; see two 2018 FIE papers [1,2] and [3-16].

Key foundational pedagogical constructs employed by the program include: research-based learning [22-23], constructivism [24], active learning [25], project-based learning [26,27], self-directed (and mentor-guided) learning [28,29]. When combined with our community of practice, and supporting activities/instruments, the program builds on a solid theoretical framework and time-proven constructs. **Contributions of Paper.** The main contributions of our paper may be summarized as follows. (1) We examine the survey data of topical concerns and critical questions ENG students want/need answers to, by the most recent cohort of 74 scholars (see two-part paper [1,2] for more details) in our ASAP program. (2) We provide a rank-based analysis on how the questions asked depend on particular scholar groups (subsets of entire cohort based) being examined. Here, the groups that we focus on are based on gender (female vs male), minority status (minority vs non-minority) and age (younger vs older). (3) Analysis of the data shows that higher risk (higher context) groups (e.g. women and underrepresented minorities) focus more on shorter-term career goals such as what the degree will buy and getting a job. Whereas lower risk (low context) groups focus more on longer-term career and life planning goals such as job advancement, life, achieving balance, job flexibility, and graduate school. The terms higher- and lower-context [34-37] - critical for understanding and meeting the

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educational, learning and professional development needs of groups - are described within the paper. Given the above, the contributions of this paper are significant and are of great relevance to FIE conference followers. **Outline of Paper.** The remainder of this paper is organized as follows. Section II provides an overview of key program resources, activities and assignments. This is presented in order to provide adequate background and context. In Section III, we provide a description of the survey used and some results (top-2 questions within each category). Section IV provides detailed data and analysis of the survey results and summarizes the main results of the paper. Section V summarizes the paper and presents directions for future work.

II. Background: Program Overview and Theoretical Framework

In this section, we provide an overview of key program resources, activities and instruments. Additional details can be found in our two FIE 2018 papers [1,2]. **Program Resources, Activities and Instruments.** Key program resources, activities and instruments are now highlighted. *Community of Practice: Mentoring and Coaching*. Key to the success of our program is a growing active community of learners and faculty-industry-peer mentors - with over 100 ASU faculty mentors. This community forms a vibrant, and foundational, community of practice. Program scholars are required to seek out and connect with multiple mentors. Mentors can assist scholars with academics, professional development, projects, career and life planning. More senior program scholars are expected to help less senior scholars at ASU (as well as at their associated CC counterparts if the ASU scholar is a CC transfer student). *ASAP Class*. While on scholarship, scholars at ASU must take our 2 credit ASAP class [1,2]. This class is the main vehicle for delivering key program resources, activities and instruments. ASAP class students are expected to improve their assignment materials from semester to semester. These include: 1) Guaranteed 4.0 Learning System time management and academic success strategies [30-33], 2) interest paper/project plan/report [1,2], 3) career plan, 4) career fair plea/pitch to prospective employers, 5) resume and cover letter, 6) graduate school statement of purpose, 7) *Fulton Undergraduate Research Initiative (FURI)* project proposal materials [1,2], 8) interacting with mentors and 9) engineering portfolio. Ten 75 minute ASAP class sessions are held each semester. Round robin discussions are the norm. Invited speakers are brought in; e.g. graduate school panel (all ASAP alumni), financial planning professional, professors, engineers, etc. $300 class incentives are offered each semester to individuals that do not receive our $4K per academic year ASAP scholarship. *ASAP Website and Program Resources*. A rich set of ASAP program/class resources (i.e. articles, outlines, sample assignments, surveys, videos, important dates, opportunities, etc.) reside on the program/class website (http://aar.faculty.asu.edu/lapdp.html) and on our Blackboard learning management system (soon to change to Canvas). These support the ASAP class and provide a "learning-on-demand" space which will be leveraged to accommodate online students in the future [47]. Content addresses research-based learning strategies, transfer success tips, life and career planning, preparing for a career fair, choosing a technical area, project planning, graduate school, life-long learning, etc. The site also serves scholars at partnering CCs. *Academic Success Strategies*. Fundamental to our academic success pedagogy are the ideas within [23,30-32] and the Guaranteed 4.0 Learning System [33]. *Interest Paper*. Our "all mighty and powerful interest paper" (as we refer to it) is the program's main foundational (project) assignment because it feeds and prepares students for all other program activities and assignments; e.g. career planning, preparing for a paid project, internship, job, career fair, graduate school, etc. (see [1,2]). *Career Fair Plea/Pitch*. All scholars are required to prepare a 1-3 minute career fair plea/pitch that will be delivered to a prospective employer at ASU's engineering career fairs (Fall, Spring). Over 130 companies (including over 480 recruiters/representatives) participate in the career fair each semester. *Developing a Career Plan*. All scholars are required to prepare a comprehensive career plan addressing academic, professional, career and life planning 10 years after graduating from ASU. *FURI Materials*. All program participants are required to prepare FURI proposal materials for ASAP class grading. Many are encouraged to submit materials to the ASU FURI proposal competition. The number of submissions have been steadily increasing for our scholars. Seventeen (17) FURI submissions were funded for Spring 2018. Twenty two (22) were funded for Fall 2018. *Surveys*. It should be noted that 14 surveys (with over 1000 questions) are used to help measure the effectiveness of key activities and instruments. **Theoretical Framework: Context Diversity.** Moving forward, we plan to more fully integrate context diversity [34-37] sensitive activities to better serve the needs of our scholars. While many individuals value higher-context (e.g. practical thinking, personalized instruction, holistic big picture thinking, demonstration-based and group oriented learning, creative learning that is internalized, communal learning spaces, information spreading rapidly and shared, information with significant context, the is encouragement of multi-tasking and a slower tempo, personal commitment to people, process oriented, informal culture, short-term feedback, room for disagreement), institutions of higher learning traditionally value lower-context (e.g. rigorous scientific interactions, general instruction, analytic thinking, direction-based and individualistic learning, creative learning that is externalized, bounded learning spaces, information not flowing too freely, information with no/low context, one thing at a time and a fast tempo, low personal commitment to people, task or goal oriented, formal culture, long-term feedback, little room for disagreement). We have learned that these matters must be properly addressed for individuals and groups to thrive. It should be noted that higher-risk groups (e.g. women, underrepresented minorities) in higher education learning environments are often shown to fall within the high-context category [34-37]. This observation is of fundamental importance in order for institutions to properly address the issues facing higher-risk groups. In view of this, our ASAP

program (currently mid- to variable-context) will be paying close attention to these issues through mentoring, discussions and surveys. Members of "higher-risk" groups like women, underrepresented minorities, low GPA, low family income, etc. are often higher-context individuals. For this reason, our "mid-context directed" *ASAP* framework is designed to address both higher- and lower-context groups.

Cohort of 74 Spring 2018 Scholars Involved in Survey. 40.5%-female, 59.5%-minority (here minority refers scholars who are either Hispanic/Latino or Black/African American), 74.32%-new scholars, 77%-transfers, 21.6%-new transfers, 93%-in state, 42% from the 9 partnering CCs, 67.56%-juniors, 28.38%-seniors, 4%-graduate, 25.6%-ME, 19.9%/4%-CS/CSE, 13.5%-EE, 10.8%-Biomed, 9.45%-ChemE, 2.7%-Aero, 4%-Civil, 5.4%-Materials, 4.65%-other, 3.40/4.0 (3.69/4.33) gpa, average age 24, 54%-working 10 hours or more/week, 18.9%-married, 14.86%-with children, 39.18%-parents with no college education, 59.4%-family income < $50K, 18.9%-no prior internship and project experience (see two-part paper [1,2]).

III. Description of Survey

In this section, we provide a description of the survey. We discuss each of the 17 key topical concerns and provide the top 2 critical questions within each topic/category. **Survey on 201 Critical Questions.** The survey used involved 201 questions (addressing 17 topics) that have been asked by ASAP program scholars since 2001. As discussed in prior work by the authors [3-16] and references within [8,10], determining questions that scholars want answered is essential for proper mentoring. Each of the 74 Spring 2018 ASAP scholars were asked to pick 20 questions that they need/want answers to from the list of 201 questions. Further, each scholar was asked to arrange their choice of 20 questions in descending order of importance by providing a ranking in the range 1-20. **Top Questions within Key Topical Categories.** To obtain "categorical/topical" insight, the 74 Spring 2018 ASAP scholars were asked to pick the most important question within each of the 17 categories. Based on this survey, the questions top-2 questions were picked within each category by the overall cohort. Here, top-2 was determined from the percentage of scholars choosing a question as most important amongst all questions within the category. The number provided below in parenthesis beside each question indicates the percentage of scholars choosing that question.

1) BS in Engineering (6 Questions). This category of questions primarily targets students that have just arrived to the program/lead institution (e.g. transfer students, freshmen) as well as community college (CC) students and high school students. Many of these students do not know what opportunities engineering offers them. The top-2 questions within this category were:

a) Why should I pursue a BS? What will a BS degree offer over a 2-year degree? Over a BA degree? What advancement Opportunities? Flexibility? Responsibilities? Salary?(29.7%)

b) I did poorly in one of my math classes. Engineering scares me. What do you suggest? Is withdrawing from a class bad? When should one do so? Is taking a class over a bad thing? When should one do so? What are the short- and long-term consequences of giving up? How important are grades? Is it true that I can get by with (and what matters most is) having a good understanding of the fundamental concepts? (16.2%)

2) Why Engineering (10). This category of questions is designed to sell students on engineering - to show students that engineers work on many (very exciting, challenging, and rewarding) cutting-edge problems that directly impact all aspects of society. The category is designed to show students that if they consider any traditional engineering discipline, finding a good (exciting, challenging, and well paying) job should not be an issue. The top-2 questions within this category were:

a) Why should I consider engineering? Will it be boring or exciting?(20.3%)

b) What exciting problems are engineers currently working on?(17.6%)

3) Choosing an Engineering Discipline (13). This category of questions attempts to address concerns about what is "traditionally done in each of the traditional engineering disciplines" as well as showing students the breadth of each discipline. The top-2 questions within this category were:

a) What do each of the following do? (Aerospace, Biomedical, Chemical, Civil/Environmental, Computer Science, Computer Systems, Electrical, Materials & Mechanical Engineering) (29.7%)

b) What do each of the above create? Is it true that the overlap between engineering disciplines is significantly increasing? Why?(10.8%)

4) Financing My BS in Engineering (8). Many students struggle with how to finance their education. All of our federally-supported ASAP scholars have demonstrated financial need (via FAFSA). We work hard with students to point out many avenues for financing their education. These avenues include scholarships, paid projects (e.g. university sponsored undergraduate research projects, see [1,2]), paid internships, subsidized or unsubsidized loans, etc. This category involves questions related to such issues. The top-2 questions within this category were:

a) What expenses will I have? tuition, fees, room, board, books, and other living expenses?(14.9%)

b) What financial aid exists if I pursue engineering? Who can I contact?(14.9%)

5) Why Pursue a BS In Engineering (27). This category pertains to helping students becoming familiar with the many resources that ASU provides. As a large institution, ASU offers its students many options. This includes a large (and growing) surrounding industrial complex that feeds engineering in terms of scholarships, other donations, mentoring, internships, senior design project/thesis supervision, part-time and full-time jobs, support for graduate school. The top-2 questions within this category were:

a) How do I pick a 4-year engineering school? (14.9%)

b) How is the ASU Ira Fulton School of Engineering Ranked? (10.8%)

6) Importance of A Mentor (6). We believe that one-on-one mentoring is the next critical factor contributing to student success – after financial support, personal commitment, and having a technical interest. Mentors help students answer all kinds of questions. We work hard to connect students with mentors in their fields. A community of over 100 faculty mentors have agreed to mentor our program scholars (see our two other 2018 FIE papers [1,2]). This category of questions deals with questions on mentoring. The top-2 questions within this category were:

a) What should I do during summers? take classes to reduce my course load during subsequent semesters? find any job? work on a paid research project? pursue a paid engineering internship?(NOTE: Projects/internships can significantly help you determine what you are truly passionate about.) (21.6%)

b) How do I find a mentor? (17.6%)

7) The Importance of Research: Figuring Out What I Want To Do (14). We believe this to be one of the most important topics addressed within our ASAP class (required of all scholars in the program while on scholarship). The questions in this category are based on using research/projects as a vehicle for students to discover, nurture, and develop their technical passions. The fundamental idea here is that if we can get students very interested in some technical topic within their discipline, then they will be "hooked." We find this to lead to greater interest in coursework and projects. The top-2 questions within this category were:

a) How do I pick a research topic? (17.6%)

b) How do I get involved in research? (17.6%)

8) Important Skills (16). As our global economy forces greater competition, students must make sure that they have the appropriate skills to compete. The questions in this category motivates students in figuring out which soft/hard skills to pursue. The top-2 questions within this category were:

a) What are useful problem-solving skills? (23.0%)

b) What computer skills should I learn? What is C++?(13.5%)

9) Leadership, Service, & Professional Networking (8). Companies want individuals that can work independently as well as in groups. They especially want individuals that can lead groups of people. This category of questions deals with such qualities. The top-2 questions within this category were:

a) What professional organizations should I join? What do they offer? (23.0%)

b) Why are leadership skills important?How does one develop leadership skills? (20.3%)

10) Importance of Graduate School (5). As technological advances continue to accelerate, the need for advanced engineering degrees also continues to grow. Given this, the importance of graduate school receives paramount priority within our ASAP class, which is the motivation behind this category of questions. We want students to go to graduate school (not for the financial reward, albeit significant), but for the doors that the advanced degree will open. It will also provide more flexibility and security. The top-2 questions within this category were:

a) Why is graduate school important? What exciting doors will it open for me? (25.7%)

b) Why should I consider getting an MS degree in engineering? What will it offer me over a BS in engineering? Advancement Opportunities? Flexibility? Responsibilities? Salary? (25.7%)

11) Financing my MS/PhD in Engineering (16). For most students, if the finances do not work out, everything suffers. All of our ASAP program scholars have demonstrated financially need (via FAFSA). For many of the scholars, the scholarship allows them to focus on their studies rather than taking a low-paying time-consuming job that severely detracts from studying and other scholarly activities. This category involves questions related to such issues. The top-2 questions within this category were:

a) How do I pay for graduate school? (29.7%)

b) Is it true that there is more funding for those interested in pursuing an engineering MS degree? What is a research assistantship (RA)? What is a teaching assistantship (TA)? How can I prepare myself so that I can get one of these? (6.8%)

12) The MS Thesis (6). This category of questions is designed so that students can understand what an MS thesis is all about. Given our emphasis on finding a "technical passion" via projects, many of our ASAP scholars use the "project mechanism" that we strongly encourage as a vehicle for establishing a foundation for their senior design project, their undergraduate honor's thesis (required by the lead institution's Honors College) or even their MS thesis. The top-2 questions within this category were:

a) What is a Master's Thesis? (21.6%)

b) How do I pick an MS thesis topic? How can the topic help me prepare for more advanced work or help me figure out what I would like to do in the future? (18.9%)

13) Getting a PhD (8). This category of questions is designed so that students can understand what a PhD is all about. Several of our ASAP scholars started as freshman (past cohorts), selected a topic (e.g. policy making with respect to energy and global warming), and are now working on their PhD on the topic they chose as freshman. This is very inspiring to us. We know that with proper support (financial and otherwise), we can get many students to follow suit. The top-2 questions within this category were:

a) Why should I consider getting a PhD degree in engineering? What will it offer me over an MS in engineering? Advancement Opportunities? Flexibility? Responsibilities? Salary? (44.6%)

b) How do I pick a PhD thesis topic? How can the topic help me prepare for more advanced work or help me figure out what I would like to do in the future? (12.2%)

14) Starting a Company (6). Many engineering students are not interested in research - even if they really do not know what it involves. Many want to start a company – even if they don't really know what is involved here either; and even if they don't have a product in mind! We want students pursuing entrepreneurial activities to understand that many of the questions that entrepreneurs ask are similar to those asked by researchers. These questions might include, for example, what is the problem being addressed? What is the approach being taken to address the problem? What existing products are there? What are the PROs and CONs of each approach/product? What is missing? What is technically and economically feasible? Here, the goal is to get students to try to think outside of the box and to fundamentally encourage a small company entrepreneurial spirit driven by independent thinking and getting a "new" product to market. The top-2 questions within this category were:

a) How do I start a company? (39.2%)

b) What is venture capital? What is a proposal? (8.1%)

15) Choosing a Job and Job Advancement (7). Here, we try to get students to think about a few things that they have typically not given much thought to. These include: How do I choose a job? How should I weigh each of the following: engineering/technical responsibilities? flexibility? choosing what you work on? flexible work hours? working from home? day care? work conditions? work group dynamics? opportunities for advancement? location? traveling? benefits? retirement plans? bonuses? salary? etc. The top-2 questions within this category were:

a) How do I choose a job? (28.4%)

b) How should I weigh each of the following? engineering/technical responsibilities? flexibility? choosing what you work on? Flexible work hours? working from home? day care? work conditions? work group dynamics? opportunities for advancement? location? traveling? benefits? retirement plans? bonuses? salary? (16.2%)

16) Ongoing Technological Revolution (31)
This category of questions is related to technical topics of national interest and current world trends. The top-2 questions within this category were:

a) What is happening in the world of medicine? regenerative medicine? personalized medicine? organ repair? genetic code modification? biometrics? (8.1%)

b) What is happening in the world of robotics? (8.1%)

17) New Research-Based Academic Success, Learning and Critical Thinking Tips (13). This category of questions is related to innovative research-based learning methods and strategies, and the importance of critical thinking for academic success, professional development and career/life planning. The top-2 questions within this category were:

a) What is critical thinking? (17.6%)

b) How do we evaluate the quality of our thinking? (12.2%)

IV. Main Results: Analysis of Collected Data

In this section, we present the survey data and analysis for the cohort of 74 Spring 2018 scholars in our ASAP program.

Description of Rubrics/Metrics for Analysis. As discussed above, the 74 scholars were asked to pick 20 of the 201 questions that they need/want answers to and arrange/list them in descending order of importance.

Rubric and Points for Critical Questions: Based on the top 20 questions picked by each student, we assign points for each critical question. The rubrics for assigning points is now described. For each student, the question that appears in 1st position in her/his list of 20 critical questions was assigned a point of 1, whereas the one that appears in 20th position in the list was assigned 0.05. For all the positions between 1 and 20, linearly spaced values were used. That is, points of [1.00, 0.95, 0.90, … , 0.15, 0.1, 0.05] were assigned to positions [1, 2, 3, … , 18, 19, 20], respectively. By using the above, in effect, we obtain a weighted score for each question. Based on this, we derive overall points/weighted score for each critical question corresponding a particular scholar group of interest (e.g., female vs male, minority vs non-minority, younger vs older). We then use these points/weighted scores to rank the questions. How was done is now explained.

Let the key categories be denoted by c_i, where $i = 1,2,3,\dots,N^c$. Here, N^c is the number of categories in the survey (which is 17). Let the questions within a category c_i be denoted by $q_j^{c_i}$, where $j = 1,2,3,\dots,N_{c_i}^q$. Here, $N_{c_i}^q$ is the number of questions in the i[th] category c_i. Since, the total number of questions in the survey is 201, it follows that $\sum_{i=1}^{17} N_{c_i}^q = 201$. Let the number of students in a particular group g_l be $N_{g_l}^s$. For example, for the overall cohort (denoted g_0), we have $N_{g_0}^s = 74$. For a student (s_k) in a group (g_l), using the list of top 20 critical questions, let the rank associated with a question ($q_j^{c_i}$) belonging to category (c_i) be denoted by $r_{c_i q_j g_l s_k} \in [1,20]$. Corresponding to each of the groups (g_l) being studied, points were assigned to each question $q_j^{c_i}$, based on the rank $r_{c_i q_j g_l s_k}$ provided by all the students in the group. This is given by:

$$P_{c_i q_j g_l} = \frac{\sum_{k=1}^{N_{g_l}^s} \left(1 - \frac{r_{c_i q_j g_l s_k} - 1}{20}\right)}{N_{g_l}^s} * 100$$

Points for Key Categories: Corresponding to each of the groups (g_l) being studied, based on the above points obtained by questions within each category, we assign points for the categories as follows. The points obtained by a category c_i is given by:

$$P_{c_i g_l} = \frac{\sum_{j=1}^{N_{c_i}^q} P_{c_i q_j g_l}}{N_{c_i}^q}.$$

Key Survey Results. In what follows, we provide the results from our survey on 201 critical questions involving our cohort of 74 Spring 2018 ASAP program scholars. First, we provide the data and analysis of top critical questions (i.e. questions with highest points obtained) selected by different scholar

groups including the overall cohort. Next, we provide the data and analysis of top categories/topical concerns.

Discussion on Top Critical Questions. Tables I-IV present the top critical questions (i.e., questions with highest points obtained) picked by different scholar groups and the corresponding points/weighted scores along with percentages of scholars picking the question in top-20 (see Section III for more details). Highlighted questions indicate that they occurred in both of the scholar groups being compared (e.g. female vs male, minority vs non-minority, younger vs older). *Overall Cohort.* The top 15 questions picked by the overall cohort (see Table I) indicate that many scholars are concerned about short- and long-term career plans and ENG job after graduation; e.g., "What exciting problems are engineers currently working on?" "Will there be a job for me when I graduate? Will it pay well? Will it be challenging/boring? Will it require traveling?" etc. Further, questions related to 4-year school, academic success, graduate school and mentoring appear in this list of top 15 critical questions; e.g., "Why should I pursue a BS?" "How do I find a mentor?" etc.

The cohort of 74 Spring 2018 ASAP scholars comes from diverse backgrounds. See Section II and our other two-part paper in 2018 FIE proceedings [1,2] for more details. It is natural to investigate the concerns of each scholar group (based on gender, minority status and age) and relate to higher- and lower-risk groups. *Gender Based Groups: Female vs Male.* Recruitment and retention of females in ENG has been a critical national issue [38-43]. Because of this issue, our ASAP program takes extra effort to address this problem and aims at significantly improving recruitment and retention. For this reason, it is important to understand what concerns females have vis-à-vis males (see Table II). (1) Female scholars are concerned much more, compared to male scholars, about questions related to short-term issues and goals; e.g. getting BS degree, what does it "buy," getting a job, etc. This is indicated by a score of 30.3 for "Why should I pursue a BS? What will a BS degree offer over a 2 year degree? Over a BA degree? What advancement opportunities? flexibility? responsibilities? salary?" for females versus 20.3 for males (which is below top 5 and hence not shown in Table II). This is also indicated by a score of 32.2 for "What is the engineering work environment like?" for females versus 21.6 for males. (2) Male scholars are concerned much more, compared to female scholars, about questions related to long-

TABLE I. TOP CRITICAL QUESTIONS: OVERALL

Overall (74 Scholars)	
Critical Question	**Points (Percentage)**
What do engineers in different ENG disciplines do?	35.5 (50.0%)
Will there be a job for me when I graduate? Will it pay well? Will it be challenging/boring? Will it require traveling?	34.2 (48.6%)
What exciting problems are engineers currently working on?	26.3 (37.8%)
What is the engineering work environment like?	25.9 (47.3%)
Why should I pursue a BS? What will a BS degree offer over a 2 year degree? Over a BA degree? What advancement Opportunities? Flexibility? Responsibilities? Salary?	24.4 (51.3%)
What professional organizations should I join? What do they offer?	24.3 (43.2%)
Why should I consider engineering? Will it be boring or exciting?	22.2 (44.5%)
How should I weigh each of the following: engineering/technical responsibilities, flexibility, choosing what you work on, flexible work hours, working from home, day care, work conditions, work group dynamics, opportunities for advancement, location, traveling, benefits, retirement plans, bonuses, salary?	20.9 (39.2%)
How do I find a mentor?	19.2 (33.8%)
Does a BS in engineering prepare me for today's rapidly changing world?	18.3 (32.4%)
What are the GREs? MCATs? LSATs? GMAT? PCAT? Are these exams difficult? How do I prepare?	17.5 (36.5%)
When should I consider switching jobs? companies? How do I prepare for this? How often should expect to switch jobs?	14.4 (28.3%)
What are useful problem-solving skills?	13.5 (29.7%)
I did poorly in one of my math classes. Engineering scares me. What do you suggest? Is withdrawing from a class bad? When should one do so? Is taking a class over a bad thing? When should one do so? What are the short- and long-term consequences of giving up? How important are grades? Is it true that I can get by with (and what matters most is) having a good understanding of the fundamental concepts?	12.8 (16.2%)
How do I pay for graduate school?	12.7 (22.9%)

TABLE II. TOP CRITICAL QUESTIONS: GENDER BASED

Female (30 Scholars)		Male (44 Scholars)	
Critical Question	**Points (Percentage)**	**Critical Question**	**Points (Percentage)**
Will there be a job for me when I graduate? Will it pay well? Will it be challenging/boring? Will it require traveling?	37.5 (66.7%)	What do engineers in different ENG disciplines do?	41.5 (52.3%)
What is the engineering work environment like?	32.2 (60.0%)	Will there be a job for me when I graduate? Will it pay well? Will it be challenging/boring? Will it require traveling?	32.0 (36.4%)
What exciting problems are engineers currently working on?	31.8 (43.3%)	What professional organizations should I join? What do they offer?	23.0 (40.9%)
Why should I pursue a BS? What will a BS degree offer over a 2 year degree? Over a BA degree? What advancement Opportunities? Flexibility? Responsibilities? Salary?	30.3 (53.3%)	What exciting problems are engineers currently working on?	22.5 (34.1%)
Why should I consider engineering? Will it be boring or exciting?	28.7 (46.7%)	How should I weigh each of the following: engineering/technical responsibilities, flexibility, choosing what you work on, flexible work hours, working from home, day care, work conditions, work group dynamics, opportunities for advancement, location, traveling, benefits, retirement plans, bonuses, salary?	22.3 (11.4%)

term career path and work-life balance. This is indicated by a score of 41.4 for "What do engineers in different ENG disciplines do?" for males versus 26.8 for females. This is also indicated by a score of 22.8 for "How should I weigh each of the following: engineering/technical responsibilities, flexibility, choosing what you work on, flexible work hours, working from home, day care, work conditions, work group dynamics, opportunities for advancement, location, traveling, benefits, retirement plans, bonuses, salary?" for males versus 18.3 for females. *Minorities vs Non-Minorities*. Similar to females in ENG, minorities have been a major risk-group which faces recruitment and retention issues [44-46]. In our ASAP program, we take extra effort to address this problem and aim to significantly improve recruitment and retention. For this reason, it is important to understand what concerns minorities have vis-à-vis non-minorities (see Table III). Here minority refers scholars who are either Hispanic/Latino or Black/African American. (1) Minorities are concerned much more, compared to non-minorities, about shorter-term issues and goals, such as, getting a BS degree, what it will "buy," getting a job, etc. This is indicated by a score of 33.0 for "Why should I pursue a BS? What will a BS degree offer over a 2 year degree? Over a BA degree? What advancement Opportunities? Flexibility? Responsibilities? Salary?" for minorities versus 19.1 for non-minorities (which is below top 5 and hence not shown in Table III). This is also indicated by a score of 37.1 for "What is the engineering work environment like?" for minorities versus 19.0 for non-minorities. (2) Non-minorities are concerned much more, compared to non-minorities, about longer-term career path and work-life balance. This is indicated by a score of 27.1 for "What professional organizations should I join? What do they offer?" for male versus 19.8 for minorities. This is also indicated by a score of 21.8 for "How should I weigh each of the following: engineering/technical responsibilities, flexibility, choosing what you work on, flexible work hours, working from home, day care, work conditions, work group dynamics, opportunities for advancement, location, traveling, benefits, retirement plans, bonuses, salary?" for non-minorities versus 19.3 for minorities.

Age Based Groups: Age < 21 vs Age ≥ 21. Our ASAP program caters to the needs of scholars belonging to a relatively wide age range (19-37 years). When mentoring students, it is important to note distinctions associated with distinct age groups. (1) Both age groups are concerned about both short- and long-term career goals (see Table IV); "Will there be a job for me when I graduate? Will it be well? Will it be challenging/boring? Will it require traveling?" "What do engineers in different ENG disciplines do?" (2) Younger scholars are concerned more about future work-life balance. This is indicated by a score of 31.9 for "How should I weigh each of the following: engineering/technical responsibilities, flexibility, choosing what you work on, flexible work hours, working from home, day care, work conditions, work group dynamics, opportunities for advancement, location, traveling, benefits, retirement plans, bonuses, salary?" for younger scholars versus 17.3 for older scholars.

TABLE III. TOP CRITICAL QUESTIONS: ETHNICITY BASED

Minorities (28 Scholars)		Non-Minorities (46 Scholars)	
Critical Question	**Points (Percentage)**	**Critical Question**	**Points (Percentage)**
What do engineers in different ENG disciplines do?	46.4 (64.3%)	What do engineers in different ENG disciplines do?	28.9 (41.3%)
Will there be a job for me when I graduate? Will it pay well? Will it be challenging/boring? Will it require traveling?	43.8 (64.3%)	Will there be a job for me when I graduate? Will it pay well? Will it be challenging/boring? Will it require traveling?	28.5 (39.1%)
What exciting problems are engineers currently working on?	37.1 (50.0%)	What professional organizations should I join? What do they offer?	27.1 (47.8%)
What is the engineering work environment like?	37.1 (64.3%)	How should I weigh each of the following: engineering/technical responsibilities, flexibility, choosing what you work on, flexible work hours, working from home, day care, work conditions, work group dynamics, opportunities for advancement, location, traveling, benefits, retirement plans, bonuses, salary?	21.8 (43.5%)
Why should I pursue a BS? What will a BS degree offer over a 2-year degree? Over a BA degree? What advancement Opportunities? Flexibility? Responsibilities? Salary?	33.0 (53.6%)	What exciting problems are engineers currently working on?	19.7 (30.4%)

TABLE IV. TOP CRITICAL QUESTIONS: AGE BASED

Age <21 (18 Scholars)		Age >=21 (56 Scholars)	
Critical Question	**Points (Percentage)**	**Critical Question**	**Points (Percentage)**
Will there be a job for me when I graduate? Will it pay well? Will it be challenging/boring? Will it require traveling?	45.3 (61.1%)	What do engineers in different ENG disciplines do?	37.4 (51.8%)
Why should I pursue a BS? What will a BS degree offer over a 2 year degree? Over a BA degree? What advancement Opportunities? Flexibility? Responsibilities? Salary?	39.4 (72.2%)	Will there be a job for me when I graduate? Will it pay well? Will it be challenging/boring? Will it require traveling?	30.7 (44.6%)
Why should I consider engineering? Will it be boring or exciting?	34.7 (50.0 %)	What exciting problems are engineers currently working on?	26.8 (39.3%)
How should I weigh each of the following: engineering/technical responsibilities, flexibility, choosing what you work on, flexible work hours, working from home, day care, work conditions, work group dynamics, opportunities for advancement, location, traveling, benefits, retirement plans, bonuses, salary?	31.9 (55.6%)	What professional organizations should I join? What do they offer?	25.8 (46.4%)
What do engineers in different ENG disciplines do?	29.7 (44.4%)	What is the engineering work environment like?	25.4 (44.6%)

Discussion on Top Categories/Topical Concerns. Table V presents the top categories/topical concerns (i.e., categories with highest points obtained) picked by different scholar groups and the corresponding points/weighted scores along with percentages of scholars picking the question in top-20

(see Section III for more details). Here, "cn" indicates category number n, where n can be any integer between 1 and 17. These categories were described in Section III above. Highlighted categories indicate that they occurred in both of the scholar groups being compared (e.g., female vs male, minority vs non-minority, etc.).

TABLE V. TOP QUESTION CATEGORIES

Overall (74)	
Category	**Score**
c2	16.1
c1	12.7
c6	9.1
c10	8.8
c15	8.6

Female (30)		Male (44)	
Category	**Score**	**Category**	**Score**
c2	19.5	c2	13.8
c1	16.8	c10	10.6
c15	9.7	c6	10.0
c6	7.8	c1	9.8
c4	7.1	c15	7.9

Minorities (28)		Non-Minorities (46)	
Category	**Score**	**Category**	**Score**
c2	19.7	c2	13.9
c1	14.3	c1	11.7
c6	11.6	c15	9.3
c10	10.4	c4	8.3
c5	8.8	c9	8.1

Age <21 (18)		Age >=21 (56)	
Category	**Score**	**Category**	**Score**
c2	19.7	c2	14.9
c1	18.3	c1	10.9
c15	10.2	c6	8.9
c6	9.9	c10	8.8
c4	8.9	c15	8.2

Overall Cohort. The top 5 categories picked by the overall cohort (see Table V) indicate that many scholars are concerned about categories related to opportunities engineering offers them and about traditional engineering discipline, finding a good (exciting, challenging, and well paying) job, finding a mentor, and graduate school. *Gender Based Groups: Female vs Male*. (1) Female scholars are concerned much more, compared to male scholars, about categories related to shorter-term issues and goals, such as, financing BS degree. This is indicated by a score of 7.1 for "Financing My BS In Engineering" for females versus 6.3 for males (which is below top 5 and hence not shown in Table V). (2) Male scholars are concerned much more, compared to female scholars, about graduate school. This is indicated by a score of 10.6 for "Importance of Graduate School" for males versus 6.3 for females. *Minorities vs Non-Minorities*. (1) Minorities are concerned much more, compared to non-minorities, about short-term issues such as, getting BS degreee. This is indicated by a score of 8.8 for "Why pursue a BS in ENG" for minorities versus 2.8 for non-minorities. (2) Non-minorites are concerned much more, compared to minorities, about longer-term issues such as leadership and professional networking. This is indicated by a score of 8.1 for "Leadership, Service and Professional Networking" for non-minorities versus 4.4 for minorities. *Age Based Groups: Age $<$ 21 vs Age $\geq$ 21. (1)* Younger scholars (age $<$ 21 years) are concerned much more, compared to older scholars (age $\geqslant$ 21 years), about categories related to shorter-term issues and goals, such as, financing BS degree. This is indicated by a score of 8.9 for "Financing My BS in Engineering" for younger versus 5.9 for older scholars (which is below top 5 and hence not shown in Table V). (2) Older scholars are concerned much more, compared to younger scholars, about graduate school. This is indicated by a score of 8.8 for "Importance of Graduate School" for older versus 5.9 for younger scholars.

Conclusions Based on Above Observations. In this section, we presented data and analysis on results from survey on top critical questions and topical concerns associated with several important scholar/student groups. Overall, we see that higher-risk groups (women and underrepresented minorities) are more concerned about critical questions/ topical concerns related to short-term career goals, whereas lower-risk groups are more concerned about long-term career and life planning. In a higher education learning environment higher-risk groups are often shown to fall within the higher-context category [34-37]. They can be benefited from personalized instruction, holistic big picture thinking, learning based on demonstration, group oriented and communal learning space, slower tempo, short-term feedback, etc. Also, we notice that younger scholars are concerned about higher-context aspects whereas older scholars are concerned about lower-context aspects.

V. SUMMARY AND FUTURE DIRECTIONS

In this paper we presented data and analysis on topical concerns and critical questions that engineering students want/need answers to. This is based on a survey associated with a list of 17 topics containing 201 critical questions. Data was presented for a cohort of 74 Spring 2018 scholars in our ASAP program at ASU. It was shown how the list of selected critical topics and questions varies from one scholar group to another based on gender, minority/non-minority and age. Analysis of the data showed that higher-risk groups focus more on shorter-term career goals while lower-risk groups focus more on longer-term career and life-planning goals. Here, we observe that the higher-risk groups such as females, minorities and younger scholars have concerns associated with higher-context individuals. Moving forward, we intend to better understand the topical concerns of scholars in our program. This will include understanding the impact of family education and family income (i.e. individuals who from a family where neither parent received a college education and/or where the combined family income is less than $50K) on student concerns/questions and their predispositions/misconceptions. A comprehensive contextual diversity study will help us shape our ASAP program practices, activities and instruments in order to better serve our students. This will require a much more careful examination of the importance of context diversity and how it impacts different groups with respect to critical concerns as well as a broad range of success metrics. A fundamental is to determine methods, with measurable outcomes for maximally sustaining vibrant ASAP communities of practice, that can be institutionalized.

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