A Comprehensive *Academic Success and Professional Development (ASAP)* Framework that uses Career-Steering/Shaping Projects to Train Engineering Students and Develop Critical Life/Professional Skills: Part I - Impact on Key Groups

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***Abstract*—**This Research to Practice Full Paper (Part I) presents a comprehensive *Academic Success and Professional Development (ASAP)* mentoring-scholarship program framework – built on a community of practice (consisting of learners and faculty-industry-peer mentors) – that uses career-steering/shaping projects as a central tool to motivate and train engineering students for the many challenges/opportunities before them. Key organizational principles, themes, activities and instruments driving the Arizona State University (ASU) program are described. While currently focusing on upper-division transfer students, the program (supported by NSF/industrial funding since 2001) also serves upper-division non-transfers and some graduate students. Data for the most recent cohort of 74 scholars shows how different groups were impacted by key program activities/instruments. The data shows that projects – specifically our "interest paper" – can prepare students for many critical activities; e.g. choosing a technical area, career planning, choosing potential employers, preparing for a career fair, getting a paid project/internship, career planning, preparing for graduate school, preparing for the engineering workforce, the ongoing technological revolution, problems of national importance, and lifelong learning. While this paper (Part I) focusses on the program and how career-steering/shaping projects can be used to prepare engineering students, Part II provides a case study for 14 scholars conducting funded research projects.

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

I. Introduction and Motivation

In this section, we summarize the state of the art associated with training engineering students, shed light on unresolved issues, motivate the problems to be addressed, and the contributions of the paper.

Overview: Background, State of the Art, Major Unresolved Issues & Problem Being Addressed. Even though the world is undergoing an unprecedented technological revolution with driverless vehicles, reusable rockets, smart air-ground-and-water robots, regenerative medicine, personalized medicine, internet of things, cloud computing [1-3], it is still difficult to recruit, motivate and train the engineering talent needed to meet anticipated needs across the nation. Because of this, mentoring-scholarship programs like ours have emerged in order to train talent at home and alleviate pressures to continuously import talent from abroad [4,5]. Such programs combine mentoring with relevant timely activities and instruments [6-20]. Despite considerable effort [21], the following pressing questions still remain:

(1) How do 4- and 2-year universities/community colleges (CCs) across the nation build win-win partnerships to best recruit, empower, retain, train and place engineering students? To address this need, we have developed a student-and-project-centric engineering (ENG) *Academic Success and Professional Development (ASAP)* mentoring-scholarship program that has been funded by the *National Science Foundation* (NSF) since 2001. Here, ENG is short for engineering and includes all traditional engineering disciplines (i.e. aerospace, biomedical, chemical, civil and environmental, computer systems, electrical, industrial, materials, mechanical) as well as computer science and engineering management. 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.

(2) How do we effectively motivate, teach, and prepare engineering students for the ongoing technological revolution and the many challenges that lie before them? Here, our solution lies in career-shaping/steering projects in areas of national importance supported by, and feeding, other ASAP activities/instruments.

In this paper, as well as in Part II [19], we answer (1) by describing our ASAP mentoring-scholarship program. We then proceed to focus our attention on (2) by describing a comprehensive framework for using projects and associated activities to address each of the aforementioned issues.

Contributions of Paper. The main contributions of our paper may be summarized as follows. We show how

(1) our ASAP program with its *Engineering Transfer Excellence Academy* mentoring-scholarship project-centric framework – similar to an honor's college, but focused on professional development [6-20] – can be used to address the recruitment, retention, training, placement issues facing 4- and 2-year institutions across the nation,

(2) projects can be used to capture the imaginations of students and provide substantive motivation and direction to fuel and guide their journey ahead,

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(3) projects can be used to help students deeply understand prior/current/future coursework, help with longer term career planning, shorter-term professional development and even shorter-term academics,

(4) projects can be used to help students prepare for career fairs, paid projects, internships, jobs and graduate school, participating in the ongoing technological revolution, working in areas of national importance and preparing for lifelong learning,

(5) specific groups are impacted by project and other supporting constructs/themes/activities/instruments,

(6) to help shape one's potential for success as an engineering student and (eventually as an) engineer through our so-called "interest paper." In short, the interest paper serves as a key mechanism for helping students choose a technical area, get started on a potentially career-steering/shaping project, prepare for paid project experiences, help with project planning/execution/reporting, identify potential employers, prepare for a job fair, develop skills to help get an internship or job, prepare for graduate school, prepare for entrepreneurial opportunities and much more.

Given the above, the contributions of the paper are significant and 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 our ASAP mentoring-scholarship program, key program themes, activities and instruments. This includes a description of the theoretical constructs that we rely on to ensure individual and group "buy in, growth and success." Section III describes our project-centric framework – how students become aware, take control and pursue excellence (ACE). Key instruments and supporting/downstream activities are also described; e.g. interest paper, choosing a technical area, career planning, career fair, finding a mentor, applying for internships, paid projects, jobs and graduate school. Section IV contains the main results of the paper – summarizing the data that has been collected and analyzed. Section V then summarizes the paper and presents directions for future work.

II. Background: Program Overview and Theoretical Framework

In this section, we provide an overview of our ASAP scholarship-mentoring program (housed within ASU's Fulton Schools of Engineering), key themes and instruments. We also describe the essential theoretical constructs that we exploit to promote buy in, comfort, enthusiastic participation, growth and success – for individuals and for the entire community of active learners and mentors that the program serves.

Overview of ASAP Scholarship-Mentoring Program: Key Themes, Activities and Instruments. Our *ENG ASAP Transfer Excellence* scholarship-mentoring program has been operational (with NSF/industrial funding) since 2001 – serving lower-division as well as upper-division students since 2001. In 2004, we shifted more toward meeting the needs of incoming CC transfer students – a growing constituency. Our emphasis on pursuing and preparing for graduate school would soon follow. The increased emphasis on career-steering/shaping projects is new, starting Fall 2017 with our new NSF 5-year, 10 Arizona institution grant - focused on upper-division ENG students and (some) graduate students who started with us as undergraduates. All program participants are required to be working on a career-steering/shaping project in an area of national importance [1-3]. Here, projects are intended to capture the imagination of students – providing them with a mechanism for discovering, nurturing and developing their technical passions. The current paper focusses on activities at ASU (lead 4-year institution).

Central to the program at the lead institution is a 2 credit ENG ASAP class that all scholars (upper-division and graduate) are required to take while on scholarship [6-20]. Key themes include becoming aware of opportunities, taking control and pursuing excellence (ACE). Key topics include exploiting our ASAP Academy framework – a community of learners and mentors forming a community of practice [24,25], academic and transfer success strategies, active and self-directed learning [26,27], project- and discovery-based learning [28-30,42], critical thinking [37], having and choosing a technical area, the importance of big picture thinking [29,30,34], defining where you're going, participating in the ongoing technological revolution, importance of lifelong learning in our increasingly global economy, picking a technical project topic, finding a mentor and graduate school. The following are the key seven (7) class assignments: (1) academic success via Guaranteed 4.0 Learning System [31], research-based learning strategies [32-34] and critical thinking [37][1], (2) resume and cover letter, (3) preparing for a career fair (i.e. career fair plea/pitch to prospective employers), (4) comprehensive career plan (i.e. 10 years past graduation), (5) interest paper (project planning, execution and reporting) – main assignment, (6) ASU *Fulton Undergraduate Research Initiative (FURI)* materials for class grading[2], (7) statement of purpose for graduate school, (8) interacting with mentors and (9) engineering portfolio. In this paper, considerable attention will be paid to the main assignment: the interest paper. A critical idea here, unique (we believe) to our approach [6-20], is that students are expected to improve their assignments from semester to semester – adjusting goals/objectives and integrating relevant math, science, engineering and other class machinery as they progress through the curriculum. As such, the program continuously promotes student-centric and collective improvement. It starts with becoming aware, progresses to taking control and finally to pursing measurable excellence (ACE).

Theoretical Framework: Constructivist Active Project-Based Learning within a Community of Practice, Retention, Context Diversity. Our program builds on

[1] It must be noted that even though institutions of higher learning offer hundreds of amazing classes, they often do NOT offer a class on how to learn, what works and what doesn't work. As such, we address this essential life skill in our ASAP program.

[2] It should be noted that students are not required, but are highly encouraged, to submit their FURI materials to the university proposal competition.

theoretical constructs that have been shown to work through rigorous empirical studies. These include a constructivist active (self-directed and mentor-guided) project/discovery-based learning approach [26-30] exploiting a growing community of learners and (faculty, peer, industry) mentors that provides a vibrant community of practice (COP) [24,25]. Critical COP principles that directly apply to our program (work in progress) are as follows (see [24,25], [6-20]):

(1) Career-Steering Projects. At the heart of our program are career-steering projects – required of all scholars. In short, we (and our scholars) view projects as a fundamental mechanism to help students properly digest coursework, learn new material/concepts/software/hardware, discover and nurture their technical passions, gain confidence, develop proficiency, organize and consolidate ideas, connect different areas, interact with clubs/organizations, network and develop a dependable "career compass." More concretely, it can help them prepare for a career fair, interviews, internships/jobs, senior design capstone project, other (paid) projects, undergraduate honor's thesis/project, entrepreneurial opportunities/pathways, graduate school, statement of purpose, research planning, fellowship opportunities, graduate (MS/PhD) theses/projects, longer-term career opportunities and life-long learning

(2) Scholarships and Project Support. Our ASAP scholarships are $4K per academic year [6-20] (~ 40% in-state ASU tuition). Additional support is provided for selected summer ASAP projects and project supplies/materials. The latter facilitates projects that could not be otherwise pursued.

(3) METS Center. Most activities take place within our Motivated Engineering Transfer Students (METS) Center. Here, class meetings are held, students study, work on carerer-steering/shaping projects and socialize. It serves as a home-away-from-home. It has a conference room with video conferencing, a large community area with computers, the director's office and a kitchen. The center also serves as an intelligent systems project/laboratory/innovation facility.

(4) Identity: Common Background and Direction. While the program focusses on upper-division ENG transfer students (77% of Spring 2018 cohort of 74 scholars), it serves many non-transfers (23% of 74 scholars), and some graduate students (4% of 74 scholars; former undergraduate program alumni). Scholarship recipients must be academically qualified (GPA > 3.0), exhibit financial need via FAFSA and either be US citizens, nationals, permanent residents or alien refugees. A shared domain of interest is provided by our focus on ENG ASAP, exciting career-steering/shaping projects in areas of national importance [1-3], seeking paid projects, internships, jobs, preparing for graduate school, participating in the ongoing technological revolution and developing skills to help participants thrive in an "increasingly technologically advanced and smaller" world. The above (and shared activities below) provides a shared context that promotes a sense of purpose, belonging, membership, and drive that fuels the desire to participate, excel and help one another [22,23]. The common focus and purpose provides comfort, fosters mutual respect, creates trust, enables individuals to take chances and be "brave." This promotes sharing of tacit (difficult to transfer via writing) and other knowledge, which, in turn, promotes individuals and the community to learn, diffuse existing knowledge, organize, collaborate, generate new knowledge, and grow socially, academically, and professionally. As members grow professionally, they collectively develop a "shared practice;" i.e. a collection of resources, tools, frameworks, constructs, concepts, approaches, methodologies, experiences, stories, etc. that can be used to address recurring problems associated with academics/learning, professional development, career, and life (in general) [6-20,24,25]. Through these interactions new knowledge is created – by individuals and by the community.

(5) Student-Centric: Opportunity for Personal and Professional Fulfilment. The program is explicitly designed to be student-centric to help students fulfill their individual needs and goals. At the heart of the program is the idea that all program scholars must work on career-steering/shaping projects in an area of national importance. Such areas have included: embedded systems, driverless vehicles, reusable rockets, smart air-ground-and-water robots, coordination of robot swarms, regenerative medicine, personalized medicine, prosthetics, internet of things, cloud computing machine learning, big data, data mining, smart sensing, distributed decision making, portfolio management system optimization [1-3]. Ideally, we'd like all of of our students to use projects to help them discover, nurture and develop their "technical passions." This, in turn, we've found leads to sustained motivation and resiliency. Our project-based approach [28-30,42] combines time-tested ideas from problem/inquiry-based learning [30] and situated learning [25] with constructivist (spiral building/organization) theory [39]. As explained later, the project – starting with our "interst paper" – can be used to prepare for many opportunities awaiting students; e.g. paid projects, career fair, internships, jobs, senior design capstone projects, honor's theses, graduate school, graduate work, graduate theses, entrepreneurial ventures, and much more.

(6) Broad Membership (Different Levels of Participation): Participants include i) program director (first author), ii) program staff (all alumni), iii) students: juniors, seniors, graduate students, iv) faculty-industry-student mentors v) career coaches, vi) a project evaluation team - all committed to our ASAP community of practice and principles. What is expected of juniors is different from what is expected of seniors, etc. Over 100 ASU faculty have agreed to mentor our scholars;

(7) Opportunity for Continuous Open Communication, Transfer and Creation of Knowledge and Varying/Distinct Perspectives. Ten (10) 75 minute ASAP class meetings are held each semester. They include round-robin class discussions about anything related to the program and what students experience. Personal discussions with individual

students are also vigorously accommodated. In addition, students engage in project meetings, group project meetings, and group assignments. More senior members (in good standing) are required to mentor less senior members. New members observe the practices of more senior members. If they are transfer students, they can bond with their more senior CC alumni – important for minimizing transfer shock [6,17,18,21] and ensuring transfer success [17,18]. Students are encouraged to become members of technical project groups, clubs and student/professional organizations – thus having access to more resources. We use SLACK as our community communications forum. It provides a virtual meeting place and discussion forum. A SLACK contact list is made available to all program participants. Our SLACK communications forum also provides a virtual meeting space and discussion forum. To assist students further with communications, an anonymous google form is used to permit anonymous critique. This complements our 24 program (14 student) surveys. Such critique and formative/summative assessment/evaluation is essential to facilitate timely constructive feedback, action and changes to program activities, processes, and instruments. Finally, and very importantly, students have access to (faculty, industry and peer) mentors and career coaches to provide expertise, guidance, knowledge transfer, and even collaborative assistance.

(8) Impactful Connectedness: Shared Activities and Events. What scholars do (e.g. for group assignments, projects, career fair, classes, etc.) transfers over to and impacts other scholars. Sample ASAP assignments (e.g. career plans, interest papers/reports, statement of purpose, resumes, cover letters, etc.) are provided on our website and on Blackboard (learning management system currently used at ASU; will be changing to Canvas) for all to see. In order to promote maximal bonding and communication amongst members, shared activities and events are vital; e.g. class sessions with round robin discussions for students to learn from one another, special seminars, special project sessions, summer project sessions, mixers (NEW). These are designed/intended to combine familiarity, excitement and emotional connectedness. Food is served at each meeting.

(9) Right Pace. Short surveys are collected after every ASAP class meeting to get immediate feedback on any program topic or issue confronting a student. Ensuring the right pace [31,32] is essential so that scholars are not overwhelmed. Critical temporal separation of academics, professional development, career planning, and life planning can be visualized as shown in Figure 1 (next page).

(10) Program Resources. A rich set of program resources reside on the program's website and Blackboard (soon to change to Canvas). These (outlines, sample materials, videos, articles, etc.) support the ASAP class and provide a "learning-on-demand" space which will be leveraged to accommodate online students in the future [41]. Available videos on our website address: 1) ASAP Overview, 2) Research-Based Learning Tips (Make It Stick), 3) Tips Part 1 - Philosophy, Critical Thinking, Planning, 4) Tips Part 2 - Learning, Health, Happiness, Productivity, 5) Guaranteed 4.0 Learning System, 6) A Primer on Finding a Mentor, 7) Comprehensive Career Planning, 8) All Mighty and Powerful Interest Paper, Plan and Project Summary, 9) Transfer Success Tips, 10) Why Graduate School?, 11) A Simple Career Fair Formula, 12) Preparing for a Career Fair.

Unlike work/project teams, a COP is more informal (less structured) and more opportunity-driven (less goal-oriented). In comparison to social networks, COPs are less informal (more structured) and less opportunity-driven (more goal-oriented). As such, a COP serves as a reasonable intermediary between teams and networks – providing a suitable balance of structure-versus-informalness and goal-versus-opportunity-driven.

It should be noted that through our ASAP class, our COP also incorporates ideas from each of the following: active learning (learning by doing) [26,27], exploratory project-based learning to help connect theory with practice ("integrating knowing and doing" [28-30,42]), learning community [24,40,43], diffused innovation [44], cognitive apprenticeships [45].

(11) Recrutiment from Partnering CCs. Finally, our transfer student-centered program relies on recruitment from partnering community collegs (CCs). We have formed strong partnerships with 9 Arizona CCs. At the heart of the partnership is the idea that ASAP scholars at partnering CCs will be maximally exposed to our ASAP best practices, principles, themes, activities, instruments and community of practice. ASAP scholars at partnering CCs have access to our ASAP website and program materials, videos, etc. Key assignments for CC scholars are 1) Academic Success Guaranteed 4.0 Learning System assignment, 2) interest paper, 3) career plan, and 4) statement of purpose to ASU Fulton (4 year lead ENG institution). CC liaisons apply standards suitable to the level of their students – requiring different standards for sophomores vis-à-vis freshmen. We are very lucky to have very strong partners in our CC liaisons. More details on our CC partnerships and relevant data will be presented in future papers.

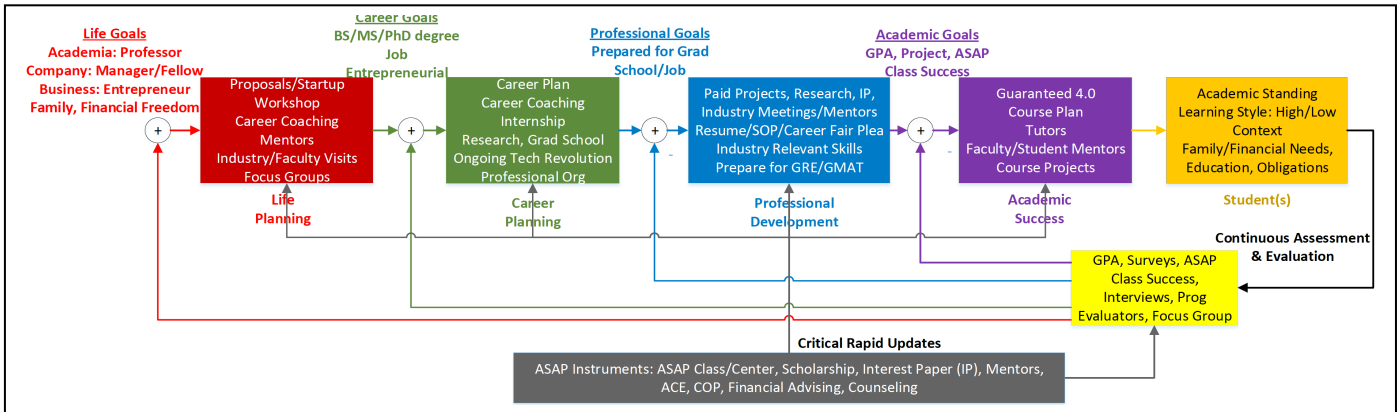

Figure 1: Visualization of Hierarchical Inner-Outer Feedback Loop Encompassing Life Planning, Career Planning, Professional Development and Academic Success within a Community of Practice (COP)

Developing a Successful ENG Transfer Program. The above leads naturally to the question: What is required to develop a successful ENG transfer program? Given this, we now provide a list of key ingredients that have served us well: 1) Program Plan/Philosophy: support students academically, socially, and financially, 2) Passionate Program Leaders, 3) Strong Community College partners, 4) Transfer Center: a place for students to meet, study, network, get questions answered from staff, to call "home," and hopefully contains a kitchen, 5) Passionate, creditable Center Director (BSE, MS in engineering) and staff (successful transfer students), 6) For credit ASAP class (2 credits works well) with supporting materials (outlines, samples, videos), 7) The Guaranteed 4.0 Learning System [33] as the basis for the ASAP Class, 8) Refreshments to make the students feel "special," 9) Scholarships to hold students accountable, allow them to work less and focus on academics/career and 10) Institutional Commitment. While it is difficult to build and sustain a successful ENG transfer program, it must be noted that much of the above can be implemented at partnering 4- and 2-year schools across the nation. Getting sustained scholarship support (as we have done), however, is particularly difficult. It should be noted that ASU ENG offers a 1 credit (one time) Transfer Success class (modeled after our 2 credit ASAP class). This is just one step toward institutionalizing our ideas.

New Hierarchical Planning/Learning Perspective. At the heart of our program is teaching students to manage the critical temporal interactions between short-term academics (week to week), longer-term professional development (5 week time scale), even longer-term career planning (25 week or half year time scale) and life planning (2.5 year time scale). At the smaller time scales ("inner feedback loops"), learning is more bottom-up. As we move toward the larger time scales ("outer feedback loops"), learning is observed to be more top-down. Modeling, understanding and managing these dynamics is a central goal of the program's research agenda. This temporal interaction can be visualized using the control-theoretic hierarchical inner-outer feedback loop diagram in Figure 1. Future work will attempt to quantify proper time scales for each of the above loops – the idea being that if an outer loop drives an inner loop too fast, instability can result [46]. The factor of five given above for the relative time scales is based on common inner-outer control practice across a wide range of application areas; e.g. air-ground-water vehicles, robotics, chemical/semiconductor processes, embedded systems, artificial intelligence, bio- socio-economic systems. Within the vehicle community, an inner loop may control speed while outer loops can control slower quantities; e.g. position, paths, waypoints, and setting trip goals. Given this, our hierarchical feedback perspective of learning has enormous qualitative justification. We will pursue quantitative results in the future. **Retention.** Since the inception of our program, we have relied on Vincent Tinto's "essential" retention principles [48]. This includes (1) setting high expectations, (2) providing student-centric academic, professional, career, social and financial support, (3) providing continuous feedback and assessment for students to gauge progress, (4) providing opportunities for social engagement (involvement) between students, faculty and staff (e.g. mixers). It must be noted that when we fail to do any of these properly, problems typically arise. **Context Diversity.** Moving forward, we also plan to more fully integrate context diversity [49]. While many individuals value high context (e.g. practical thinking, personalized instruction, holistic big picture thinking, demonstration-based learning, group oriented, creative learning internalized, communal learning space, information spreading rapidly and shared, information having context, multi-tasking encouraged and slower tempo is, high personal commitment to people, process oriented, informal culture, short-term feedback, room for disagreement), institutions traditionally value low context. These must be properly addressed for individuals and groups to thrive. It should be noted that high risk groups (women, underrepresented minorities, etc.; see below) in higher education learning environments are often shown to fall within the high context category [49]. This observation is of fundamental importance in order for institutions to properly address the issues facing high risk groups. In view of this, our ASAP program (currently mid-context and variable context) will be paying close attention to these issues through mentoring, discussions (group and one-on-one) and surveys. See paper submitted to FIE 2018 describing critical questions

ENG students want/need answers to and how the questions asked depend on the group being examined [20]. **General Program Data, Successes and Trends.** To date, the program has been very successful – serving as a model for programs across the nation; very consistently achieving over 95% graduation rates for upper-division scholars and more than 50% going on directly to ENG graduate school – the latter being more than twice the national average [6-20,23].

III. Career-Steering/Shaping Projects

As stated earlier, we want all scholars to become aware, take control and then pursue excellence (ACE). This is done through various instruments. Our primary interest is what we call "The Almighty and Powerful Interest Paper." We refer to it this way because it helps students with so much. Here is a short list of what it helps students with: 1) choosing a technical area, 2) defining and planning a career-steering/shaping project (required of all program participants), 3) choosing a mentor, 4) choosing a potential employer, 5) developing critical skills listed in company job postings, 6) planning for a career fair, 7) writing a 1-3 minute career fair pitch to potential employers, 8) preparing for paid internships, 9) preparing for a full time job, 10) preparing for interviews, 11) preparing for a paid projects (e.g. FURI, Western Alliance to Expand Student Opportunities (WAESO); see Part II [19] summarizing 14 such projects), 12) preparing for a senior design capstone project, 13) preparing for an honor's thesis, 14) preparing for graduate school, 15) preparing a statement of purpose, 16) preparing for graduate work (e.g. thesis), 17) preparing for entrepreneurial ventures, 18) communicating ideas with oneself (critical thinking) [37], 19) deeply understanding prior and current classes, 20) preparing for future classes, and much more. Given the above, we view the interest paper as one of our key "drivers/indicators/predictors" of success. This will be supported by data in the section that follows.

Three Phases: Becoming Aware, Taking Control, Pursuing Excellence (ACE). As discussed above, we take a three phase ACE approach with our scholars. We first need to make them aware of the many opportunities before them. This is not easy and can be very intimidating for the students. This is done by discussing the ongoing technological revolution and the increasingly global economy. This leads naturally into how projects (in areas of national importance) can be used to take control of their careers and pursue excellence.

It must be noted that choosing a technical area for a career-steering/shaping project can be particularly intimidating for students. With so many choices before them, many students are afraid to pick. The interest paper can serve as a vehicle for facilitating this choice, seeing what areas are in demand and even identifying prospective employers. Despite our success with most students, the "technical area choice" is very difficult for some (see data below). Why? Many students are afraid to make the "wrong choice" – almost like they are afraid of being assigned to the "rock piles of hell for all eternity." We try to explain that as long as they make a reasonable choice, and proceed systematically and logically (critically thinking along the way [37]), there will be no regrets. Why? We try to explain that the same questions that one must ask to make (for example) a better plastic bottle are virtually identical for any other enterprise; e.g. designing a surgical robot, company formation, etc. The "science" may be different, but the thought process - the sequence of questions that need to be asked are the same; e.g. What is the problem being addressed? Why is it important or worthwhile? What have others done to address the problem? What are the pros/cons of their approaches? What are the current issues being examined? What can I do? Do I have a new approach? Can I combine their approaches to develop a new approach? How do I start? What is next step? etc. The point that we try to make here is: if you give a topic your all and ask the right questions (see above), then the skills you learn will directly transfer over to any enterprise you choose down the road. We also explain that in today's rapidly changing technological world, it is common for professionals to change jobs every 7 or so years [50]. This too is a scary reality for students. While critical thinking and life-long learning attempt to address most of the above, they're still not given the attention required. This is another reason why programs like ours are important and require broader adoption. **Outline for Our Interest Paper.** It has been argued above that an interest paper can support many activities. Supporting data is presented below in Section IV. The following is an outline of our "almighty and powerful interest paper." It consists of questions we want students to think about and answer. We strongly believe that all ENG students should be required to write an interest paper every semester. (1) *Technical Area Chosen*: What technical area have you chosen? (2) *Importance of the Chosen Area*: Why is this area important? How does this area currently impact the nation/world? (3) *Problemo be Pursued*: What problem (or family of problems) within the above area are you interested in pursuing? (4) *Importance of the Problem to be Pursued*: Why is your chosen problem important? If the problem were solved, what would the impact be? (5) *Relevant Career Prospects*: What relevant companies (or laboratories), which you may pursue in the future, "play" (operate) in the above space? (6) *Approaches and State-of-the-Art*: What have others done to address the problem(s) you've chosen? What approaches have been taken? Try to describe each approach or the most widely taken approaches. What are the PROS/CONS of each approach? (7) *Your Approach to Problem*: What approach (or approaches) do you plan on pursuing? (8) *Rationale for Approach*: Why are you taking the above approach? (9) *Risk-Reward*: What are the chances for success? What will you gain by pursuing the above? What are the chances for failure? What obstacles do you foresee? Do you possess the necessary background or skill set? What are the obstacles? (What don't you know? What resources are you lacking?) How do you plan to address each obstacle? If you pursue the above, what is the worst possible scenario in terms of your career? (10) *Preparation To-Date*: What in your past has prepared you for the above endeavor? (11) *Special Relevant Skills*: What special relevant skills do you possess? (12) *Required Resources and Budget*: A list of required resources is especially useful when applying for a paid project (FURI, WAESO) for which a budget is required. (13)

Timeline: Use a Gantt chart to provide a timeline indicating major milestone dates. (14) *Future Plans*: What are your future plans to help you prepare for the above endeavor? (15) *References*: Provide a comprehensive list of references (e.g. conference/journal papers, undergraduate/MS/PhD theses, articles, URLs, presentations, etc.). It should be noted that given our student-centric ASAP success mission, we are constantly trying to improve each of our instruments. As such, the above outline should be viewed as a work in progress.

IV. Main Results: Analysis of Collected Data

This section summarizes data collected from 14 electronic surveys with nearly 1000 questions. (1) *Data for Fall 2017 Cohort of 90 Scholars*: 44%-female, 36%-minority, 71%-new scholars, 77%-transfers, 20%-new transfers, 93%-in state, 44% from the 9 partnering CCs, 62%-juniors, 31%-seniors, 7%-graduate, 36%-ME, 19%/3%-CS/CSE, 16%-EE, 10%-Biomed, 10%-ChemE, 5%-Aero, 4%-Civil, 4%-Materials, 3%-other, 3.48/4.0 (3.76/4.33) gpa, average age 24, 53%-working 10 hours or more/week, 21%-married, 17%-with children, 45%-parents with no college education, 60%-family income <$50K, 63%-no prior internship and project experience. After the semester, 16 scholars left program: 4 graduated in Dec 2017, 5 in May 2018. Students in final semester of degree sometimes leave in order to focus on a few credits, honor's thesis, etc.; 1 pursuing PhD with Fellowship; 1 ENG internship (full time); 1 accident; 2 withdrew (family obligations); 2 new transfers left ENG . (2) *Data for Spring 2018 Cohort of 74 Scholars:* 40.5%-female, 59.5%-minority, 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. The remaining data presented in this paper is for this cohort of 74 scholars. It should be noted that 17 graduated in Spring, 2 left because of family obligations, 2 doesn't need scholarship and 1 graduated with MS, 1 new transfers left ENG. *Academic Success Data: Research-Based Learning Strategies, Transfer Success Tips, Critical Thinking:* 85% of the students feel that all engineering students should learn the research-based academic success strategies that we employ. When students follow proven success strategies (e.g. for studying and exam taking), it helps significantly. 93% claim to follow Guaranteed 4.0 Learning System [33] on a regular basis. 67% of gpas went up with the cohort average gpa rising from 3.76 to 3.77. The gpas of new transfers (continuing transfers) went from 3.77 (3.76) to 3.67 (3.78) - hence no appreciable "transfer shock'' was seen [6,17,18,21]. New scholar gpa went down: 3.79 to 3.78; Continuing scholars gpa went up: 3.7 to 3.75; Regulars gpa went up: 3.77 to 3.82. Some students struggle with time management. Students whose gpa dropped (33%), said time management was the main issue. New scholars (74.32% of 74 total scholars) were not exposed to the Guaranteed 4.0 Learning System before the program. Time management is a key component of the Guaranteed 4.0 Learning System. For this reason, we often see new scholars (especially new transfers) experiencing time management problems initially. In future, this will be remedied (in part) by exposing all ASAP scholars at our partnering CCs to the Guaranteed 4.0 Learning System.

Professional Development Data: Interest Paper, Career Planning, Career Fair, Graduate School. Project Areas: Technical project areas selected were as follows: 1) Robotics, Computing, Intelligent Systems - 26%, 2) Control, Embedded, Systems - 16%, 3) Medical, Genetics, Manufacturing-17%, 4) Modeling, Design, Manufacturing - 8%, 5) Energy - 7%, 6) Automotive, Intelligent Systems, Artificial Intelligence - 7%, 7) Materials - 5%, 8) Infrastructure, Sustainability, Environment - 7%, 9) Modeling, Simulation, Algorithm - 4%, 10) Computing, Systems - 3%. Key reasons for area selection (> 84%) were: "cool, exciting, challenging and provides good foundation..." Selection was based on reading/internet/media (29%), faculty/teachers (28%), IP/prior project (25%), families/friends/engineers/scientists/organizations/clubs(18%). 40% found area hard to choose (24% new scholars, 16% continuing) – 33% with gpa < 3.8, 32% transfers, 22% males, 21% minorities. Scholars with gpa < 3.8 find it hard to pick technical area, whereas those with gpa > 3.8 find it easier. Why? 78% of scholars with gpa > 3.8 value intellectual responsibility, autonomy, and perseverance much more than empathetic attributes (e.g. empathy, humility, fair mindedness). Only 33% of scholars with gpa < 3.8 value intellectual responsibility, autonomy and perseverance above the empathetic attributes. *Interest Paper*: With an interest paper (IP) getting students started on career-steering/shaping projects, 86% felt all ENG students should do an IP. 76% felt the IP helped with company research and their career fair pitch. 66% of scholars felt that the IP helped them figure out what they want to do in the future. (Remaining 34%: 28% new scholars, 6% continuing scholars; 27% new transfers, 7% regulars/non-transfers; 24% with gpa<3.8, 10% at or above 3.8). 81% felt that IP can help plan their next critical career-steering/shaping project; the same for FURI/WAESO or a paid summer ASAP project; the same for deciding where they would like to work (e.g. company, national laboratory, university). 78% felt that the IP can help them with that very important face-to-face career fair plea. 37% had problems with IP and its use for career planning – 34% new scholars, 30% new transfers, 23% gpa<3.8. New scholars who are also new transfers (21% of 74 total scholars) often experience difficulties in seeing how the IP can be used for career planning (46% had problems versus 37% overall). This is typically an issue when they deal with these concepts for the first time. This too will be remedied in the future by exposing all ASAP scholars at partnering CCs to this concept and the full power of the IP. *Career Fair:* The Fall 2017 career fair involved 147 employers, 500 recruiters/company representatives and 3556 students/alumni. The Spring 2018 career fair involved 138 employers, 484 recruiters/company

representatives and 3027 students/alumni. Each semester, career services provides a 75 minute seminar and 3 career coaches (all scholars) for our program/center (22 hours/week total). All scholars registered with the career center and its company research tool Handshake. 84% believe these will be useful. 45% couldn't find enough job openings at fair (40%-transfers, 36%-new scholars). 78% want help researching companies/jobs (64%-transfers, 56%-new scholars, 43%-gpa < 3.8). The following helped with company research: company seminars/websites/job postings (48%), IP (20%). Scholars scored their resumes 4.1/5. 88% found resume checklist useful. 45% had difficulty figuring out what to include/exclude on resume. 60% spent 3-9 hours (<3 hours: 14 %, > 9 hours: 26%) preparing for career fair (46%-transfers, 46%-gpa < 3.8, 38%-new scholars); 1.5 hrs with coaches, 2 with career services, 2.9 with Handshake, 2.9 on resume. Class round-robin practice/critiquing, followed by self-practice, helped the most with their pitch. 53% practiced pitch 15-60 minutes (60-120 minutes: 19%, 120-180 minutes 10%, over 180 minutes: 4%). New scholars and new transfers also experience problems with finding suitable companies at the career fair and deciding what information to place on resumes. This can be attributed to lack of experience with past jobs and projects (69%/54% of new scholars lacked past job/project experience and 94%/88% of new transfers lacked past job/project experience). *Graduate School*: With over 50% of our past scholars going on to ENG graduate school directly, our success here has been great. Students are receiving our MS/accelerated-MS message well. Writing a statement of purpose is hard for many students (40%), but helps everyone think and plan. 72% of our BS scholars want to go to graduate school. 94% of these say graduate school will provide valuable knowledge to solve technical problems, find a fulfilling job and improve job prospects. All current MS scholars (4, Spring 18) plan to go for a PhD. 39% want 4+1 (accelerated) MS, 12% MS here, 8% MS elsewhere, 7% direct PhD here, 6% direct PhD elsewhere. *Mentoring*: Scholars want (and need) one-on-one mentoring. 84% of the scholars had 2-4 faculty mentors. 79% seek mentoring on research opportunities in their area; 53% seek mentoring on developing technical skills (Remaining 47%: 38% with gpa < 3.8, 34% new transfers, 30% new scholars); 94% of faculty mentors wish to mentor students on research/project opportunities. Most (68%) of the remaining 47% mentioned above (not wanting mentoring on developing technical skills), wanted mentoring on academic success, developing soft professional skills and preparing for graduate school. *Key Observation: Interest Paper as a Possible Driver/Predictor of Success:* The above and following data suggests that our interest paper is an effective instrument and possibly a potential indicator of success: 58 (78%) of the cohort (74 scholars) received an A (90 or more) on our interest paper assignment. From these 58 scholars, 76% (44) received an A on their career fair plea, 91% (53) an A for their statement of purpose, 83% (48) an A for their career plan, 76% (44) an A for their FURI materials, 29% (17) received a FURI funding for Spring 2018, 40% (23) received FURI funding for Fall 2018, 48% (28) have a Summer 2018 internship, 71% (41) are planning to pursue a graduate degree – 41% (37) a 4+1 (accelerated) MS, 17% (15) an MS and 13% (11) a direct PhD. Continuing scholars, who have had more experience preparing and using the IP, the connections to other assignments/activities develop clarity. This, in turn, helps them think more critically [37]. Given the above, we view the IP as a driver/predictor for "success." This, of course, requires further data collection and careful analysis. This will include focus groups and much more.

V. Summary and Future Directions

In this paper we have presented an ENG ASAP Transfer Excellence framework for 4- and 2-year schools to recruit, retain, empower, train and place ENG students. The framework uses projects to assist students with career planning, job hunting, preparing for graduate school and much more. Statistics were presented to show how various groups are impacted. Our interest paper was shown to be a critical instrument for promoting success. Critical lessons learned are as follows: (1) even the best and brightest students need individual one-on-one mentoring to pick a path and stay on course. Students have problems (2) picking a technical area and formulating a problem statement for a project, (3) deciding which companies to approach at a career fair and how to prepare or acquire the needed skills, (4) developing a comprehensive career plan, (5) finding and selecting suitable mentors, (6) fully understanding the many opportunities before them and developing strategies and tactics to properly address them (e.g. paid projects, senior design, internships, graduate school, fellowships). **Future Plans/Directions.** Based on our analysis of the data collected to date, future work will address (1) how to more effectively determine individual student (high/low context, learning, mentoring) needs, helping them get started and determining their next step, (2) helping students to more concretely relate classes, projects and internships to future goals, (3) deploying more team assignments to encourage networking, (4) helping students find suitable mentors and help strengthen mentor-mentee connections, (5) assisting students with choosing a technical area, project/problem formulation, (6) helping students research companies and developing skills sought in job postings, (7) helping students prepare for opportunities before them (e.g. paid projects, senior design, internships, graduate school, fellowships), (8) reaching out to online students (a rapidly growing demographic), (9) making sure students get answers to critical questions (see 2018 FIE [20]), (10) determining how student success is impacted by their high/low context disposition, learning style, personality type, and traditional ASAP measures/activities, (11) collecting student data from CC partners using our ASAP materials and assisting partners to maximally expose their scholars to ASAP best practices, themes, activities and instruments. The latter will be addressed through bidirectional visits (as in the past) and videoconferencing. Finally, we'll continue to work hard to determine how to best grow and sustain a robust community of practice that can be institutionalized.

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