A Comprehensive *ASAP* Framework that uses Career-Steering/Shaping Projects to Train Engineering Students & Develop Critical Life/Professional Skills: Part II – Case Studies from Students Working on Funded Projects

Dr. Armando A. Rodriguez, Pragyan A. Pradhan, Karan Puttannaiah, Nirangkush Das, Kaustav Mondal, Aratrik Sarkar, Shubham Sonawani, Shi Lu, Kimberly Bui, Charles Cederstrom, Carolyn Christie, Zakk Giacometti, Corey Kurowski, Nikki Lopez, Bryce Pedroza, Tanner Rosenthal, Mohamed Sabet, Bhavica Soni, Trae Waggoner

Abstract**—** This Research to Practice Full Paper (Part II) describes how students, working on paid projects, have benefited from a comprehensive engineering *Academic Success and Professional Development (ASAP)* mentoring-scholarship project-centric program at Arizona State University (ASU) – and the associated community of practice (consisting of learners and faculty-industry-peer mentors) – described within Part I. The program, while focusing on upper-division transfer students, serves upper-division non-transfers and some graduate students as well. Central to the program is that scholars must participate in career-steering/shaping projects in an area of national importance. In this paper, 14 scholars are considered. All 14 scholars were mentored by the main author (professor and director of the NSF-funded program). For each scholar, we describe the impact of key program activities/instruments/constructs/projects on the scholar and the group of 14 scholars considered. All were selected to pursue funded projects - 11 for Spring 2018, 8 renewed for Fall 2018, 3 for new Fall projects and 11 for summer 2018 projects. For each scholar, their projects and future plans are described. The group of 14 scholars is also compared to the larger cohort of 74 scholars described in Part I in terms of key program activities/outcomes.

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

I. Introduction and Motivation

Overview: Background & Problem Being Addressed. This paper, as well as Part I [16], is motivated by the need to recruit, retain, empower, train and place students in the engineering workforce in order to meet national needs [1]. 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. Here, ENG is used to represent all traditional engineering disciplines (i.e. aerospace, biomedical, chemical, civil and environmental, computer systems, electrical, industrial, materials, mechanical), including 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. This paper, as well as Part I [16], 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 [45]; see FIE 2018 Part I [16] and [2-17].

Key foundational pedagogical constructs employed by the program include: research-based learning [18-19], constructivism [20], active learning [21-22], project-based learning [23-24], self-directed learning [25]. When combined with our community of practice, and supporting activities and instruments, the program builds on a solid theoretical framework and time-proven constructs [2-17].

Central to the program is that all scholars must participate in career-steering/shaping projects in areas 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 [26,32-42]. Ideally, we'd like all of our students to use projects to help them discover, nurture and develop their "technical passions." This, we've found, leads to sustained motivation and resiliency. As explained in Part I [16], the project – starting with our "almighty and powerful interest paper" – can be used to prepare for many opportunities awaiting students; e.g. projects like the paid projects described in this paper, career fair, internships, jobs, senior design capstone projects, honor's theses, graduate school, graduate work, graduate theses, entrepreneurial ventures, and much more. The interest paper (and project) can specifically assist with academic, professional development, career and life planning. Here, paid projects refer to ASU *Fulton Undergraduate Research Initiative (FURI)* projects, ASAP program summer projects

A.A.Rodriguez is the Director of the *Southwest Institute for Engineering Transfer Excellence (SWIETE),* a senior member of IEEE and a Professor in the School of Electrical, Computer & Energy Engineering (ECEE), Arizona State University (ASU), Tempe, AZ, aar@asu.edu. P.A.Pradhan, S.Sonawani and S.Lu are MS students in ECEE. K.Puttannaiah is a PhD candidate in ECEE. N.Das is an MS student in the School for Engineering of Matter, Transport & Energy (SEMTE). K.Mondal and A.Sarkar are PhD students in ECEE. K.Bui and N.Lopez are BS students in SEMTE. C.Cederstrom is a BS Student in the School of Sustainable Engineering & the Built Environment. C.Christie, C.Kurowski, T.Rosenthal, M.Sabet and T.Waggoner are BS students in ECEE. Z.Giacometti, B.Pedroza and B.Soni, and are BS students in the School of Computing, Informatics and Decision Systems Engineering.
This work has been supported, in part, by NSF Grant No. 1565177.

978-1-5386-1174-6/18/$31.00 ©2018 IEEE

and summer projects funded by the *Western Alliance to Expand Student Opportunities (WAESO)*.

Contributions of Paper. The main contributions of our paper may be summarized as follows. (1) We show how 14 Spring 2018 ASAP scholars (11 of which are co-authors) – funded to work on paid projects have been impacted by program activities, instruments and the projects. Eleven (11) of the 14 were funded for, and completed, Spring 2018 ASU FURI projects. Of these, 8 were funded to continue their FURI projects into the Fall 2018. Three (3) were also funded to begin new Fall 2018 FURI projects. Eleven (11) of the 14 will be working on ASAP Summer 2018 projects (with ASAP program financial support). Four (4) students will receive additional funding to work on Summer 2018 WAESO projects. (2) The case studies presented in this paper provide examples of successful research-to-practice successes – shedding light on how key ASAP program activities (e.g. career planning, interest paper, career fair, career-steering project) have impacted the students. Comparisons to the larger cohort of 74 scholars described in Part I (FIE, 2018) [16] are presented.

Given the above, the contributions of this paper (Part II) are significant, complement those contained withn Part I [16] well and are of great relevance to FIE 2018 conference attendees.

Outline of Paper. The remainder of this paper is organized as follows: Section II provides an overview of key program resources, activities, instruments and foundational principles. Section III presents case studies for 14 scholars that were selected to work on paid projects. Section IV summarizes the paper and presents directions for future work.

II. Background: Program Overview

In this section, we provide an overview of our ASAP program (see Part I [16] for more details).

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. 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 [27-31], 2) interest paper/project plan/report [16], 3) career plan, 4) career fair plea/pitch to prospective employers, 5) resume and cover letter, 6) graduate school statement of purpose, 7) FURI project proposal materials, 8) interacting with mentors and 9) engineering portfolio. Ten 75 minute ASAP class sessions are held each semester. Round robin discusssions 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; see resources above). These support the ASAP class and provide a "learning-on-demand" space which will be leveraged to accommodate online students in the future [46]. 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, etc. The site also serves scholars at partnering CCs. *Academic Success Strategies*. Fundamental to our academic success pedagogy are the ideas within [27-30] and the Guaranteed 4.0 Learning System Assignment [31]. *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 Part I [16]). *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 500 recruiters) participate in the carreer 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 afer 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.

It should be noted that scholars at partnering CCs watch provided ASAP class videos and complete 4 key assignments: Guaranteed 4.0 Learning System, career plan, interest paper and statement of purpose for ASU Fulton ENG. Subsequent papers will provide further details on CC partner activities.

Theoretical Framework: Project-Based Learning within a Community of Practice. Our program builds on theoretical constructs that have been shown to work through rigorous empirical studies [2-17]. Fundamentally, we take an active constructivist self-directed project/discovery-based learning [23-25] approach exploiting a growing community of learners and (faculty, peer, industry) mentors that provides a vibrant community of practice (COP) [21,22]. Critical COP principles that directly apply to our ASAP program (a work in progress) are now highlighted (see [2-17], [21,22]). *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. *Scholarships and Project Support*. Our ASAP scholarships are $4K per academic year [2-16]. Additional support is provided for selected summer ASAP projects and project supplies/materials. *METS Center*. Most activities take place within our *Motivated Engineering Transfer Students (METS) Center*. Here, class meetings are held, students study, students work on career-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 facility for scholars to work alongside other scholars and with affiliated graduate students (e.g. 7 co-authors). *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%), and some graduate students (4%; all 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 unifying "shared domain of interest" is provided by our focus on ENG ASAP, exciting career-steering/shaping projects in areas of national importance [50], seeking paid projects (e.g. FURI, ASAP, WAESO), internships, jobs, preparing for graduate school, participating in the ongoing technological revolution and developing skills to help participants thrive in an "increasingly technologically advanced 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 [21,22]. *Student-Centric: Opportunity for Personal and Professional Fulfilment*. The program is designed to be student-centric to help fulfill the needs and goals of individuals. 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. Our project-based approach [16] combines time-tested ideas from problem/inquiry-based learning [22,23] and situated learning [22] with constructivist theory [20]. *Broad Membership (Different Levels of Participation)*. Program participants include i) the program director (Rodriguez), ii) program staff (all alumni), iii) scholars/students: juniors, seniors, graduate students, iv) faculty-industry-student mentors, v) career coaches (ASAP scholars), vi) a project evaluation team - all committed to our ASAP community of practice principles. It must be noted that what is expected of juniors is different from what is expected of seniors, etc. Over 100 ASU faculty have agreed to mentor our scholars. *Opportunity for Continuous Open Communication, Transfer and Creation of Knowledge and Varying/Distinct Perspectives*. Our 10 (75 minute) ASAP class meetings (each semester) include many round-robin class discussions about anything related to the program, opportunities 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 [14] and ensuring transfer success [15]. To facilitate networking, we use SLACK as our community communications forum. It provides a virtual meeting place and discussion forum. *Impactful Connectedness: Shared Activities/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, career fair pitch, resumes, cover letters, FURI project proposals, statement of purpose, 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. Food is served during class meetings to enhance discussions and connectedness. Additional mixers/seminars are also held. *Right Pace*. Short surveys are collected after every ASAP class meeting to get immediate feedback on any program topics. Ensuring the right pace [44] is essential so that scholars are not overwhelmed. Critical temporal separation of academics, professional development, career planning, and life planning is addressed in [16] (Part I paper, 2018 FIE, see Figure 1). ***Recruitment from Partnering CCs***. Our transfer student-centered program relies on recruitment from partnering 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. *Retention*. Since the inception of our program, we have relied on Vincent Tinto-like retention principles [47]: (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 make adjustments to more seamlessly incorporate the importance of context diversity [48]. While many individuals value high context (i.e. practical thinking, personalized instruction, holistic big-picture thinking, demonstration-based learning, group oriented, creative learning is internalized, communal learning space, information spreads rapidly and shared, information should have context, multi-tasking is encouraged and tempo is slower, personal commitment to people is high, process oriented, informal culture, short-term feedback, room for disagreement), institutions traditionally value low context. These two “extremes” must be properly addressed for individuals and groups to thrive. It should be noted that higher risk groups (e.g. women, underrepresented minorities, etc.; see below) in higher education learning environments are often shown to fall within the high context category [48]. 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- 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 [17]. Also see prior papers [7,9].

General ASAP Program Scholar Data for Spring 2018. The following is relevant data for our Spring 2018 cohort of 74 scholars: 40.5%-female, 59.5%-minority, 62%-female/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; Major: 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, 8.9%-married, 14.86%-with children, 39.18%-parents with no college education, 59.4%-family income < $50K, 100%-have financial need, 18.9%-no prior internship or project experience. See Part I [16] for more data. The above data shows that many of our scholars come from “at risk” groups (see underlined statistics). Despite this, it is important to note that we have been able to achieve greater than 90% graduation rates for years – with over 50% going on directly to graduate school (over twice the national average) [2,3,11-13]. This success is attributed, in part, to time-tested ASAP activities, instruments, practices, a growing community of practice involving many faculty-industry-peer mentors and funding from NSF. When our program is compared to others across the nation [51], one sees that we uniquely combine most constructs, activities and approaches that have been pursued over the past decade – our program pioneering most [2-17]. Accomodating the projects of 70-100 ASU ENG scholars across 11 broad categories (see [16]) (with a large mentoring force – over 100 faculty, 35 engineers, 100 peer mentors) is very unique and forward looking.

III. Case Studies: Students Working on Projects

In this section, we present (anonymized) case studies for 14 ASAP program scholars funded for (paid) projects. Eleven (11) of the students are co-authors. The other three (3) will begin their significant project work over the summer/fall of 2018.

Data for 14 Scholars and Comparisons to Larger Cohort. In this paper, we focus on 14 of our Spring 2018 ASAP scholars. For each student (see table below), we examine: major, gender, age, ethnicity, transfer status (new, continuing or regular non-transfer), new or continuing scholar, academic

	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	Avg/Cohort
1. Gender	M	F	M	F	M	M	M	F	M	M	M	M	F	F	F:36/41%
2. Age	23	20	22	19	40	22	23	22	19	20	21	22	20	21	22.4/24.2
3. Ethnicity	TMR	H/L	W	W	H/L	TMR	W	H/L	W	H/L	W	W	A	AA	*1/*2
4. Transf Stat	NT	R	NT	R	NT	NT	NT	CT	R	R	NT	CT	NT	R	*3/*4
5. Acad Lev	J	J	J	S	J	J	J	J	J	J	J	J	J	J	J:93/68%
6. Major	ME	ME	CE	EE	EE	CSE	EE	ME	CSE	CSE	EE	EE	EM	CSE	*5/*6
7. Resume*	A/4	A^+/5	A^+/5	A^+/4	A/4.5	A/5	A^+/5	A/4	A^+/4.5	A^+/4.5	A^+/5	A^+/5	A^+/4	A/4	4.6/4
8. Cover Letter*	A/4	A/4.5	A^+/5	A/4	A^+/4.5	A/5	A^+/4	A^+/4	A/4.5	A/4.5	A^+/4	A/4.5	A^+/4	A^+/4	4.3/4
9. CF Pitch*	A/5	A^+/4.5	A^+/4	A^+/4	A^+/4.5	A^+/4	A^+/4	A^+/4	A^+/4.5	A/4.5	A/4	A/4	A^+/4	A^+/4	4.2/3.8
10. Career Plan*	A^+/4	A^+/4	A^+/5	A/4	A/4	A/4	A^+/4	A^+/3.5	A^+/4	A^+/4	A^+/5	A^+/4	A^+/4	A^+/3.5	4/3.9
11. IP*	A/5	A^+/5	A^+/4	A/4	A/4.5	A^+/5	A^+/4	A^+/5	A^+/4.5	A^+/4.5	A^+/4.3	A^+/4	A^+/4	A^+/4	4.2/3.5
12. FURI Mat*	A/4	A^+/5	A^+/5	A^+/4	A/4	A^+/5	A^+/5	A^+/4	A^+/5	A^+/4.5	A^+/4	A^+/4	A^+/4	A^+/4	4.4/3.9
13. SOP*	A/4	A/4.5	A^+/5	A^+/5	A/5	A^+/4	A^+/3.5	A^+/5	A^+/5	A^+/4	A^+/3.5	A^+/4	A^+/4	A^+/4	4.3
14. Sum Intern	No	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	No	No	Y:50/35%
15. CF Prep(hr)	>9	3-6	3-6	6-9	>9	6-9	>9	6-9	6-9	3-6	6-9	>9	>9	6-9	6-9/3-6
16. Mentor-FIP	2/0/0	1/1/0	1/1/0	1/3/1	1/0/1	1/1/1	1/0/1	1/2/1	1/0/0	1/0/0	2/0/2	1/0/1	3/0/1	2/0/0	*7/*8
17. Sp18 FURI	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	79/23%
18. F18 FURI	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	86/28%
19. Sum ASAP	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	93/19%
20. Sum WAESO	No	Yes	No	No	No	No	No	Yes	Yes	No	No	No	No	Yes	29/7%

M=Male, F=Female, W=White, H/L=Hispanic/Latino, TMR=(>2 Races), A=Asian, AA=Black or African Amer., NT=New Transfer, CT=Continuing Transfer, R=Regular, J=Junior, S=Senior, ME=Mech Eng., CE=Civil Eng., EE=Electrical Eng., CSE=Computer Science/Systems Eng., EM=Eng. Mgmt, *1=(W:43%, H/L:29%, AA:7%, TMR:15%), *2=(W:53%, H/L:30%, AA:8%, TMR:7%), *3=(NT:50%, R:36%, CT:14%), *4=(NT:22%, R:23%, CT:55%), *=(Assignment grade/Self grade), *5=(ME:21%, CE:7%, EE:35%, CSE:30%, EM:7%), *6: (ME:26%, CE:4%, EE:13.5%, CSE:23%, EM:3%), CF=Career Fair, IP=Interest Paper, Y=Yes, FIP=Faculty/Industry/Peer Mentors, *7=(85.7%: 2-4 mentors), *8=(86%: 2-4), H=High, L=Low.

level, performance on ASAP class assignments (i.e. resume, cover letter, interest paper, career fair pitch, statement of purpose, career plan, FURI proposal materials), how long did they prepare for career fair and what mentors do they have. Comparisons to the larger cohort of 74 scholars is also provided in the table. The table shows that, for the most part, the 14 students examined in this paper are representative of the larger cohort of 74 scholars. Some noteworthy data (not contained in the table to preserve anonymity) is now presented. The average GPA for the group (cohort) is 3.47 (3.4). The GPA range for the group (cohort) is 3.01-3.81 (2.6-3.87). GPA-wise, the group is comparable to the cohort. It should be noted that 57% (39%) of the group (cohort) comes from a family where neither parent received any college education. Finally, it should be noted that 64% (59%) of the group (cohort) comes from a family where the combined family income is less than $50K. Given the above, it follows that the group exhibits larger parental education and family income figures relative to the larger cohort. The significance of this will be further examined in future work. In terms of success metrics, it should be noted that 50% (35%) of the group (cohort) are doing a summer internship; 100% (72%) of the group (cohort) will be going on to graduate school.

Additional relevant data for the group (larger cohort) is now provided. *Interest Paper (IP)*: Here, we present IP data for the group (and the larger cohort). 78.6% felt all ENG students should do an IP (86%). 100% felt IP helped with company research and their career fair pitch (76%). Given this, it follows that the IP is a very positive indicator. 100% felt the IP helped them figure out what they want to do in the future (66%). 100% felt the IP can help them plan their next critical career-steering/shaping project (81%). The same holds for FURI or paid summer ASAP/WAESO projects; the same for deciding where they would like to work (e.g. company, national laboratory, university). In short, all 14 scholars considered here believe that the IP helped them with career planning, company research, figuring out where they would like to work, their career fair pitch, planning their career shaping/steering project and paid project(s) and planning what they want to do in the future. While most did not need much help writing the IP (i.e. felt the provided outline was sufficient), several expressed some concerns. This is addressed below under case studies. *Mentoring*: 85.7% (86%) have 2-4 faculty mentors. Here, the group and cohort are comparable. Scholars want (and need) one-on-one technical mentoring. 71.4% (79%) seek mentoring on research opportunities in their area. 75% (53%) seek mentoring on developing technical skills. Here, we hope to improve the cohort figure. 92.8% (98%) seek mentoring on finding jobs and internships. Here, the group and cohort are comparable. 50% (62%) seek mentoring on paying for graduate school and financial options they have. As shown below, the group has thought a great deal about graduate school and paying for it (e.g. fellowships). *View Points on Learning and Planning*. The following data shows how the group (and larger cohort) viewpoint changed after one semester (8-17 to 3-18). The data suggests enhanced viewpoints for both the group (and the larger cohort). How did the group (larger cohort) feel about 1. Research-based academic strategies on 8-17: 74% (74%); on 3-18: 100% (85%). 2. Guaranteed 4.0 System on 8-17: 88% (85%); on 3-18: 100% (93%). 3. Career Planning on 8-17: 92% (88%); on 3-18: 100% (92%). *Key Assignment Grades*. The following data shows how the group (and larger cohort) grades on key assignments compared during the Spring 2018 semester. The data shows that the group did very well on key assignments (relative to the larger cohort). The entire group – 100% - received either an A or A+ on each assignment. The larger cohort grade is in parentheses: 1. Interest paper assignment (78%). 2. Career fair plea (59%). 3. Statement of purpose (72%). 4. Career plan (65%). 5. FURI materials (59%). *Self-Grading on Key Instruments*. The following data shows how group (and larger cohort) self-grading changed over the Spring 2018 semester. Here, we give beginning of semester grades followed by end of semester grades. 1. Resume – 4.1 (3.6); 4.6 (4). 2. Cover letter – 4 (3.3); 4.3 (4). 3. Plea – 3.8 (3.7); 4.2 (3.8). 4. Career Planning – 3.8 (3.8); 4 (3.9). 5. Interest Paper – 4.2 (3.2); 4.4 (3.5). We see that the group is a bit more confident compared to the cohort.

Student-Specific Case Study Information (Anonymous). Project technical areas selected by the 14 students were as follows: (1) ground robots (7 students), (2) underwater robotics (1 student), (3) quadcopters (1 student), (4) prosthetics (1 student), (5) energy (1 student), (6) water management planning and control (1 student), (7) portfolio management (1 student), (8) research-based learning via immersive games (1 student). It should be noted that most students chose their technical area of interest because of the following reasons: it's exciting/cool, relevant to nation and people, it has many research opportunities and will help with life-long learning, will provide a good foundation to build upon and it offers flexible work conditions. Many were influenced by teachers, mentors and role models.

Below, the following case-specific information is addressed for each student: working or not, summer 2018 internship plan, was interest paper hard to write and if so which part, do they utilize study groups, use of a daily schedule and using professor office hours, what helped with academic success, mentoring sought, details about their paid projects and future plans. In short, the program has significantly impacted all 14. *Student Testimonials:* Students have said: "When I entered the program, I really knew very little about my field. That has changed. The ideas from the Guaranteed 4.0 System and Make It Stick have taught me how to learn." "The program helped me connect with other students and faculty." "Career planning helped me connect my education with the real-world. I have developed skills that I never thought I needed." "I learned so many new cool things by pursuing a project. Planning helped me get an internship at Texas Instruments." "Project funds permitted me to work on something I always dreamt of. I could not have done it otherwise." "The project gave me confidence that I was lacking. Everyone should be forced to do a project. Project funds will help me pay for next semester's tuition." "The project gave me the little push I needed to start exploring the state-of-the-art in my field. Career planning helped me step out of my comfort zone at the career fair to get the internship I wanted." "After my first semester in the program, I purposely put a great deal of time into my career plan and interest paper. I feel bad for those that don't." "Previously, I had no concrete direction, no specific goals, and did not take true ownership of my career. Now I see a future designing robots to build complex structures. Cool!" "Can't wait to write my SOP and research plan for an NSF Fellowship." **Student 1, ME**. This student is married and is currently working over the (2018) summer at a non-STEM job. The student felt that our ASAP program provided significant help with career fair plea and planning for an internship. The student closely follows a time management schedule and utilizes professor office hours (POH). Guaranteed 4.0 assignment helped with academic success; e.g. doing homework, reviewing graded homework/exams (BPC) [31]. This student sought mentoring on academic success, professional development, career plan, research and graduate school. FURI-1 (F18): Development of a Thermoelectric Generator. The main objective of the forthcoming work is to gain a deep understanding of the Seebeck (thermoelectric) effect and how it can be used to build a thermoelectric generator (TEG). This will be done by demonstrating the Seebeck effect using various materials, carefully examining a commercial TEG module and examining Seebeck coefficient calculation using fundamental thermodynamic principles. Future Plans: The planned FURI will establish a foundation for more advanced work in the energy arena. The student specifically plans to pursue similar work for his senior design capstone project and for an accelerated 4+1 MS (with project) in Mechanical Engineering. **Student 2, ME** (co-author). This student is working on summer ASAP and WAESO projects. The student is also participating in a summer research program at Purdue University. The student felt that our ASAP program provided significant help with career fair preparation. Academically, the student has been helped with study group participation and utilizing POH. This student sought mentoring on professional development, career, finance, research and graduate school. This student needed additional help writing the following sections of the IP: technical area chosen, importance of chosen area, state-of-the-art, problem to be pursued, importance of problem to be pursued, approaches, and relevant career prospects. FURI-1 (Sp18): Developing Prosthetics for Children with Disabilities to Participate in Sports. The goal of the project was to develop a comprehensive guide that summarizes the best materials to use for a prosthetic being designed to facilitate specific sport-dependent gestures. Future Plans: The above FURI has provided an excellent foundation for pursuing more advanced robotic arm research during the summer of 2018 and planning for direct PhD doctoral work in the area of prosthetics. **Student 3, CE** (co-author). This student has a summer internship with Freeport-McMoran and is working on a summer 2018 ASAP project. The student felt that our ASAP program provided significant help with career plan, resume, interviewing tips, career coaching, getting suitable mentoring, finding the right balance (school-work-personal). The student follows a schedule and utilizes POH. Guaranteed 4.0 helped with academics. This student sought mentoring on professional development, career planning, research and graduate school. FURI-1,2 (Sp,F18): Modeling, Analysis & Decision Making for Coupled Water Systems in the Presence of Significant Uncertainty. The research focused on using model-based control theory [32-34] to develop a design procedure for controlling a water resource system exhibiting common infrastructure coupling effects. Linear programming methods for optimizing the design were also explored. Using concepts from FURI-1, "leaky bucket modeling" ideas [37-39] will be incorporated to model a regional water management case study and reveal fundamental management tradeoffs. Future Plans: This student is passionate about "intelligent" (model-based) water management in the presence of uncertainty. FURI-1,2 will provide an excellent foundation to pursue the next critical goal – applying for an NSF Fellowship to fund the student's direct PhD water management work at ASU. **Student 4, EE** (co-author). This student earned a BS and is currently working full time at Orbital Sciences. The student felt that our ASAP program provided significant help with resume, cover letter and statement of purpose. Academically, the student relies on a time management schedule, reading ahead, doing practice exams, and reviewing graded homework/exams (BPC) in accordance with the Guaranteed 4.0 System [31]. This student sought mentoring on academic success, professional development, career planning, financing school and research. FURI-1 (Sp18): Design & Development of a Precision Robotic Thrower & Smart Target. This project focused on the specific goal of designing & developing a robotic arm that can precisely throw a ball to an accompanying smart target. Future Plans: This student will work as a guidance, navigation and control (GNC) engineer at Orbital Sciences before coming back for an MS at ASU. **Student 5, EE**. This student is married with children and currently working on a summer ASAP project and taking summer classes. The student felt that our ASAP program provided significant help with interviewing tips and career fair preparation. Academically, the student experienced transfer shock [14-15], participates in study groups, follows a time management schedule and relies on doing homework, practice exams and reviewing graded homework/exams (BPC) [31]. This student sought mentoring on academic/transfer success, professional development, career, finance, research and graduate school. FURI-1 (F18): Development of a Solar Powered Ground-Based Research Vehicle with an Onboard Energy Management System. The intention of this project is to build a hybrid solar powered (photovoltaic) ground vehicle (HSPGV) with an onboard solar energy management system and the ability to navigate a track in minimum time [35]. Future Plans: This project will provide an excellent step toward the student's next goal – to complete an accelerated 4+1 MS with a focus on intelligent solar powered autonomous systems. **Student 6, CSE** (co-author). This student has a summer internship with Ball Aerospace and is working on a summer ASAP project. The student felt that our ASAP program provided significant help with time management, career planning. Academically, the student experienced transfer shock [14,15] and relies on following a time management schedule, doing homework and having an organized bullet point notebook in accordance with the

Guaranteed 4.0 system [31]. This student sought mentoring on professional development, research and graduate school. This student needed additional help writing the following sections of the IP: problem to be pursued, importance of problem to be pursued and state-of-the-art. FURI-1,2 (Sp,F18): Computer Vision Navigation for Robotic Campus Guide. A strong software and hardware foundation was laid for the development of advanced robot guide navigation and control algorithms. The forthcoming FURI-2 project will seek to algorithmically improve the guide robot that was developed to guide a person from building to building on the ASU campus. Future Plans: FURI-1,2 provide an excellent foundation to achieve the next goal – apply for an NSF Fellowship to permit a direct PhD at ASU. The proposed doctoral work will focus on using robots to build complex structures. **Student 7, EE** (co-author). This student has a summer 2018 internship with Moog Broad Reach and is working on a summer ASAP project. The student felt that our ASAP program provided significant help with career fair plea, finding the right balance (school-work-personal). Academically, the student relies on study group participation, doing homework and utilizing POH. This student sought mentoring on academic success, career, financing school, research and graduate school. FURI-1,2 (Sp,F18): Image Processing, Tracking and Control for an Intelligent Autonomous Underwater Submersible Research Fleet. FURI-1 addressed image processing and tracking in underwater low-light conditions. Low speed tracking was demonstrated with a Raspberry Pi. An Nvidia Jetson TX2 board with 256 graphical processing units (GPUs) [36] was shown to provide far superior (near 30 frames per second) performance. This project was selected as one of the best FURIs for the Spring 2018 semester. FURI-2 will address the development of a low-cost underwater research-grade vehicle. The overall aim (moving forward) is to develop a fleet of low-cost, research-grade intelligent autonomous vehicles for the purpose of underwater exploration [37]. Future Plans: The student's goal is to become a professor, supervise cutting-edge research and make significant contributions in the fairly new and forward-looking research arena of underwater exploration with intelligent autonomous vehicles. The forthcoming FURI-2 work will lay down a foundation for applying for and NSF Fellowship and pursuing a direct PhD at ASU. **Student 8, ME** (co-author). This student has summer internship with L3 Aviation Products and is working on summer ASAP and WAESO projects. The student felt that our ASAP program provided significant help with academic success strategies, time management, career planning, resume, cover letter, career fair plea, interviewing tips, career coaching, getting an internship. Academically, the student relies on study group participation, following a time management schedule and utilizing POH. The student experienced transfer shock [14,15] and is now helping other CC students with this issue. This student sought mentoring on academic success, professional development and career planning. This student needed additional help writing the following sections of the IP: approaches to problem, state-of-the-art, approach to problem, rationale for approach, special relevant skills, timeline and future plans. FURI-1, 2 (Sp,F18): Development of a Ground Robot with a Simultaneous Localization and Mapping (SLAM) Capability. A differential-drive robot was developed. The algorithms within [38] were used in order to simultaneously determine where the robot was and to construct an environmental map (e.g. map of a room). This provided a foundation for more advanced work over the summer and for FURI-2. During FURI-2, a TX2 Nvidia board and an RGB camera will be added to the robot to permit rapid SLAM. These will also permit the use of much more powerful machine learning (neural network) assisted algorithms for mapping [38], object detection-and-recognition [39], path planning [40], mapping and SLAM [38]. The limitations of each algorithm will be examined. Future Plans: This student is passionate about "systems & controls." FURI-1,2 will provide an excellent foundation for pursuing an MS in the area. Over the summer, the student has a relevant internship at L3. **Student 9, CSE**. This student is working on summer ASAP and WAESO projects. The student felt that our ASAP program provided significant help with resume, cover letter, career fair plea, interviewing tips, and career fair. Academically, the student relies on study group participation, following a time management schedule, doing homework, doing practice exams and utilizing POH. This student sought mentoring on academic success, professional development, career planning, research and graduate school. This student needed additional help writing the following sections of the IP: approach to problem, rational for the approach, risk-reward assessment. FURI-1 (F18): Ground Robot with an Arm to Perform Simple Grasp and Place Tasks. The main goal of this project is to build a ground-based robotic vehicle with a mechanical arm to accomplish rapid material relocation tasks. Future Plans: The forthcoming project will provide a foundation for pursuing more advanced work and an accelerated 4+1 MS at ASU. **Student 10, CS** (co-author). This student has a summer internship with Walmart Labs. The student felt that our ASAP program provided significant help with resume, cover letter, career fair plea, Interviewing tips, career coaching, getting an internship/job. Academically, the student relies on study group participation, utilizing POH and doing homework. This student sought mentoring on academic success, career planning and graduate school. FURI-1 (Sp18): Stock Portfolio Optimization on Your Smart Phone. Data was collected for the stocks of 100 companies spanning key sectors (e.g. financial, mining, natural resources, technology, healthcare, construction, utilities) over the period 2000-2017. This included closing price, volatility, PE ratio and sentiment polarity associated with news articles. We then developed a optimization script. Two optimization criteria were pursued: (1) maximizing return subject to a risk constraint and (2) minimizing risk subject to a return constraint. We were also able to demonstrate the incorporation of news into the optimization. Future Plans: FURI-1/2 provide an excellent foundation for pursuing more advanced work in the area of machine learning and pursuing an accelerated 4+1 MS at ASU. **Student 11, EE** (co-author). This student is currently working on a summer ASAP project and is taking summer classes. The student felt that our ASAP program provided significant help with career planning, academic success strategies. Academically, the student experienced transfer shock [14,15] and relies on study group participation, utilizing POH, time management schedule, summarizing class notes (bullet point notes - BPN) [31] and having an organized bullet point notebook [31] This student sought mentoring on academic & transfer success, professional development, career planning, research and graduate school. This student needed additional help writing the following sections of the IP: approaches to problem, state-of-the-art, your approach to problem, special relevant skills, timeline, and future plans. FURI-1,2 (Sp,F18): Precision Following of a Ground Vehicle by a Quadcopter with a Go-Ahead Audio-Visual Support Capability. A quadcopter was assembled to track a ground vehicle via colored marker on the vehicle. An Nvidia TX2 was shown to achieve nearly 30 Hz high-resolution image processing. During FURI-2, the goal is to be able to tightly coordinate multiple air and ground vehicles in a space. The work will lay a foundation more advanced detection and tracking work [41,42]. Future Plans: The student's goal is to become a professor, supervise cutting-edge research and make significant contributions to robotics. FURI-1,2 lay a foundation for pursuing the next critical goal – applying for an NSF Fellowship and pursuing a direct PhD at ASU. **Student 12, EE** (co-author). This student has a summer internship with Texas Instruments and is working on a summer ASAP project. The student felt that our ASAP program provided significant help with time management. Academically, the student relies on study group participation, utilizing POH and practice exams. This student sought mentoring on academic and transfer success, professional development, career planning, research and graduate school. FURI-1,2 (Sp,F18): Separation Control and Coordination of Multiple Intelligent Ground Robotic Vehicles: An Image Processing Approach. During FURI-1, 2 two robotic vehicles were built by the student. Algorithms that make use of image processing to track/follow a vehicle were developed. Spacing control and obstacle avoidance algorithms were also developed. Additional vehicles will be built during FURI-2. All vehicles will possess hardware to permit high-speed high-resolution image processing and mapping. This work will involve significant modeling, analysis and control algorithm development – exploiting the ideas within [41]. This will permit precise speed and direction control [41,42], position control along a path, spacing control along a path [41,42] and obstacle avoidance [42]. Future Plans: The student is passionate about "systems & controls." FURI-1,2 provide an excellent foundation to pursue the next goal – applying for the NSF Fellowship to pursue a direct PhD at ASU. **Student 13, EM** (co-author). This student is currently working as a METS Center staff and is working on a summer 2018 ASAP project. This student felt that our ASAP program provided significant help with career fair plea, interviewing tips, career fair, getting a job, getting suitable mentoring, statement of purpose and finding the right balance (school-work-personal). Academically, the student experienced transfer shock [14,15] and relies on study group participation, following a time management schedule, utilizing POH and reading ahead. This student sought mentoring on professional development, career planning, research and graduate school. FURI-1 (Sp18): Development of a Multi-Sensor Intelligent Embedded System for a Guide-Robot to Assist the Blind with Mobility and Situational Awareness. A strong understanding of how to use modern sensing, computing, and alerting devices together with algorithms to build a system of wearable sensing devices was laid. The goal of the forthcoming FURI-2 project is to gain an understanding of how to use advanced sensing/hardware and algorithms to build a guide-robot to assist the blind with mobility and situational awareness. Future Plans: FURI-1,2 will provide an excellent foundation to pursue the next goal – pursue an accelerated 4+1 MS at ASU and a thesis addressing the development of robotic guides for the visually impaired. **Student 14, CS** (co-author). This student is working on summer ASAP and WAESO projects. The student felt that our ASAP program provided significant help with academic success strategies, career fair. Academically, the student relies on study group participation, utilizing POH, following a time management schedule, doing homework and doing practice exams. This student sought mentoring on academic success, professional development, career planning, financing school, research and graduate school. FURI-1,2 (Sp,F18): App Development for Intelligent Interactive Adaptive Learning Systems: Algebra Made Wonderful! Designed and implemented the Algebra Made Wonderful iOS learning application. The purpose of the app is to seamlessly bring fun interactive gaming and research-based learning principles together to provide an enhanced learning experience that can be accessed anywhere in the world at any time. During FURI-2, the goal will be to grow the application and expand its reach. Currently, the app covers (1) systems of linear equations and inequalities and some (2) quadratic functions and equations. Polynomials and factoring will be added. Future Plans: The above will provide a solid foundation for pursuing an MS degree and a thesis in the area of enhanced learning via game and immersive technologies.

IV. Summary and Future Directions

In this paper (Part II), we have shown how 14 students – funded to work on (paid) career-shaping projects – have benefited from our ENG ASAP program activities and instruments. In the future, we will draw from the lessons highlighted in Parts I and II in order to improve how (1) we connect students with mentors (in progress), (2) the interest paper helps students prepare for paid projects (FURIs/ASAP/WAESO), internships, jobs, graduate school, (3) our CC partners maximally and effectively expose their ASAP scholars to major ASAP practices, themes, activities and instruments so that when students transfer to ASU, they come in "running;" i.e. *A*ware, in *C*ontrol and already pursuing *E*xcellence – in accordance with our ENG ASAP ACE approach.

References

[1] National Science Board. Science and Engineering Indicators 2016.

[2] M.R. Anderson-Rowland, A.A.Rodriguez, "Programs for Transfer and Non-Transfer Upper Division and Graduate Engineering and Computer Sciencce Students," 2013 Amer. Soc. for Eng. and Educ. Proc., 2013, pages 8.

[3] M.R. Anderson-Rowland, et al., "METSTEP: Third Year Review," 2013 Amer. Soc. for Eng. and Educ. Proc., June 2013, pages 12.

[4] M.R. Anderson-Rowland, et al., "Why Some Community College Students Choose Engineering and Some Don't," 2013 Amer. Soc. for Eng. and Educ. Proc., 2013, pages 16.

[5] M.R. Anderson-Rowland, et al., "Determining the Community College Audience," 2012 Amer. Soc. for Eng. and Educ. Proc., 2012, pages 11.

[6] M.R. Anderson-Rowland, et al., "Leveraging S-STEM Scholarship Programs," 2012 Amer. Soc. for Eng. and Educ. Proc, 2012, pages 8.

[7] A.A.Rodriguez, M.R. Anderson-Rowland, "Critical Questions to Which Engineering Students Need Answers," 2012 Amer. Soc. for Eng. and Educ. Proc., 2012, pages 8.

[8] M.R. Anderson-Rowland, et al., "A Focus Group Evaluations of an Academic Success Program and Support System for Transfer Students," 2012 WEPAN Proc, 2012, pages 11.

[9] A.A.Rodriguez, M.R. Anderson-Rowland, "Critical Questions for Engineering Students by Gender and Ethnicity," 2012 Proc. of Frontiers in Education, pages 6.

[10] M.R. Anderson-Rowland, et al., "Making a Difference: How to Recruit More Community College Women and Underrepresented Minority Students Into Engineering and Computer Science," 2011 Amer. Soc. for Eng. and Educ. Proc., pages 9.

[11] M.R. Anderson-Rowland, et al., "STEP Grant Challenges and Results: Motivated Engineering Transfer Students From Non-Metropolitan Community Colleges," 2011 Amer. Soc. for Eng. and Educ. Proc., pages 13.

[12] A.A. Rodriguez, M.R. Anderson-Rowland, "Comprehensive framework for significantly increasing the number highly trained engineers: A model academic success and professional development (ASAP) class-lessons learned and strategies moving forward," 2013 Frontiers in Educ. Conf., pp. 1224-1230, IEEE, 2013.

[13] M.R. Anderson-Rowland, A.A. Rodriguez, "Motivated Engineering Transfer-STEM Talent Expansion Program (METSTEP)," 2010 Amer. Soc. for Eng. Educ. Annu. Conf. and Exposition, June 2010, pages 12.

[14] M.R. Anderson-Rowland, A.A. Rodriguez, "A Focus Group Evaluations of an Academic Success Program and support system for Transfer Students," 2012 WEPAN Proc., pp. 11.

[15] M.R. Anderson-Rowland, et al., "Evaluating a collaborative program to increase the enrollment and retention of community college transfer students," 35th Annu. Conf., FIE, pp. S3G—S3G, IEEE, 2005.

[16] A.A. Rodriguez et al, "A Comprehensive Academic Success and Professional Development Framework that uses Career-Steering/Shaping Projects to Train Engineering Students and Develop Critical Life/Professional Skills: Part I- Impact on Key Groups," To be published in Proc. of Frontiers in Educ., 2018, San Jose, CA.

[17] A.A. Rodriguez, et al, "Topical Concerns and Critical Questions Engineering Students Want/Need Answers To: Dependence on Key Groups," To be published in Proc. of Frontiers in Educ., 2018.

[18] J. Bransford, "Human cognition: Learning, understanding and remembering," Thomson Brooks/Cole, 1979.

[19] L. Maehr, H. Meyer, "Understanding motivation and schooling: Where we've been, where we are and where we need to go," Educational Psychology Review, vol. 9, no.4, pp. 371--409, Springer, 1997.

[20] J. Piaget, Piaget's theory, Wiley New York, 1970.

[21] M. Prince, "Does active learning work? A review of the research," Journal of Eng. Educ., Vol.3, pp. 223-231, 1993.

[22] M. Silberman, Active Learning: 101 Strategies To Teach Any Subject, Prentice-Hall, PO Box 11071, Des Moines, IA 50336-1071, 1996.

[23] H. Hadim and S. Esche, "Enhancing the engineering curriculum through project-based learning," In 32nd Annu. Frontiers in Educ., vol. 2, pp. F3F--F3F. IEEE, 2002.

[24] S. Bell, "Project-based learning for the 21st century: Skills for the future," vol.83, No.2, pp. 39–43, Taylor & Francis.

[25] R. Stewart, "Investigating the link between self directed learning readiness and project-based learning outcomes: the case of international Masters students in an engineering management course," European J. of Eng. Educ., vol.32, No.4, pp. 453–465, Taylor and Francis, 2007.

[26] F. Black, R. Littermanm, "Global portfolio optimization. Financial analysis journal," vol.48, pp. 28– 43, CFA Institute, 1992.

[27] S. A Ambrose, et al., "How learning works: Seven research-based principles for smart teaching," John Wiley and Sons, 2010.

[28] P. Brown, H. Roediger, M. McDaniel, Make It Stick, Harvard University Press, 2014.

[29] M.McCrudden, D.McNamara, Cognition in Education, Routledge, 2017.

[30] R. Paul, L. Elder, Critical thinking: Tools for taking charge of your learning and life, New York: Prentice-Hall, 2001.

[31] D. Johnson, YC Chen, Guaranteed 4.0, LLC, 2004.

[32] A. Rodriguez, Analysis and Design of Feedback Control Systems, Control3D, LLC, Tempe, AZ, 2nd edition, 2004.

[33] A.Rodriguez, Analysis and Design of Multivariable Feedback Control Systems, Control3D, LLC, Tempe, AZ, 2nd edition, 2004.

[34] A.Rodriguez, Linear Systems: Analysis and Design, Control3D, LLC.

[35] T. Lipp, S. Boyd, "Minimum-time speed optimisation over a fixed path," Int. J. of Control, vol. 87, no.6, pp. 1297—1311, 2014.

[36] Wong, William. "Supercomputer Module Doubles Performance for Faster Neural Nets." Electronic Design, 10 Mar. 2017

[37] M. Spong, et al., Robot modeling and control, vol. 3, Wiley NY, 2006.

[38] Cheein, et al. "SLAM algorithm applied to robotics assistance for navigation in unknown environments." J Neuroeng Rehabil, 7.1, pp.10.

[39] D. Maturana, "A 3d convolutional neural network for real-time object recognition," 2015 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS), pp. 922-928, IEEE, 2015.

[40] E. Galceran, "A survey on coverage path planning for robotics," Robotics and Autonomous systems, vol. 61, no.12, pp. 1258--1276, Elsevier, 2013.

[41] A. Ailon, I. Zohar, "Control strategies for driving a group of nonholonomic kinematic mobile robots in formation along a time-parameterized path," IEEE/ASME Trans. on Mechatronics, vol. 17, no. 2, pp. 326—336, IEEE, 2012.

[42] J. Van Den Berg, et al., "Reciprocal n-body collision avoidance," Robotics research, pp. 3--19, Springer, 2011.

[43] L. Alfieri, et al., "Does discovery-based instruction enhance learning?," J. of education psychology, vol. 103, No.1, pp. 1, American Psychological Association, 2011.

[44] E. Wenger, et al., "Seven principles for cultivating communities of practice, Cultivating Communities of Practice: a guide to managing knowledge," Harvard Business School Press, vol. 4, 2002.

[45] J. Lave, E. Wenger, "Situated learning: Legitimate peripheral participation," Cambridge university press, 1991.

[46] J. Friedman, "Online Education Trends to Watch in 2017," U.S. News and World Report, 1-5-2017. Available from https://www.usnews.com/highereducation/onlineeducation/articles/2017-01-05/5-online-education-trendsto-expect-in-2017.

[47] V. Tinto, "Leaving college: Rethinking the causes and cures of student attrition," University of Chicago Press, 5801 S. Ellis Avenue, 1987.

[48] R. Ibarra. Context diversity: Reframing higher education in the 21s century. Campus Compact: Boston, USA, 2006.

[49] G.W. Clough, et al., "The Engineer of 2020: Visions of Engineering in the new century", Nat. Academy of Eng., Washington, DC.

[50] National Academy of Engineering. The engineer of 2020: Visions of engineering in the new century. National Academies Press, 2004.

[51] *National Science Foundation Awards Search*. Available: https://www.nsf.gov/awardsearch/