

Research-informed service-learning in Mechatronics and Dynamic Systems

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Abstract: This paper addresses opportunities for linking research and teaching through service-learning as an experiential teaching method that combines community service with research and academic instructions, particularly related to Mechatronics and Dynamic Systems areas. The research component is complementary to the service-learning activity that applies the state-of-the-art technologies, and can potentially lead to scientific original work and world-class contributions in technological advancements. Various advanced technologies related to mechatronic systems have been developed by the authors and the students involved in such projects as part of their University curriculum, including: self-powered solar Unmanned Aerial/Ground Vehicles, energy harvesting systems, biologically inspired mechanical birds and insects, bio-inspired vertical axis wind turbines, jelly-fish inspired propulsion, nature-inspired techniques such as quantum networks, cryptography, and entanglement for multi-robotic/vehicle systems, which can be further enriched by service components. Connecting University instructions to real-world applications and cutting-edge technologies, as research-informed service-learning activities, results in engaging, attractive, and rewarding experience for the students.

To demonstrate the research-based service-learning activity, a case study is carried out at California State Polytechnic University, Pomona in collaboration with the students in the electromechanical engineering program and the Police Department. The students carry out their senior design project as a service-learning project by developing long endurance electric multi-rotor drones (with station-keeping capability) for traffic monitoring, situation awareness, and surveillance. The research goal is to overcome the limited flight time of the current drone technology (currently limited to about 30min flight) using buoyancy force and solar energy (without recharging the onboard batteries, or using tethered drones). The service-learning goal is to help the police department in applications of drones for monitoring and situation awareness while operating for long periods of time, and the capability of a wide monitoring coverage area.

The Innovation to Flight (I2F) Student Program at the Jet Propulsion Laboratory is introduced as a practical example of the service-learning paradigm, with many beneficial goals including:

Enhance and develop future mission capabilities; rapid innovation, rapid and affordable access to space for innovators; train, inspire, and motivate the next generation of aerospace engineers through immersion into flight by rapid design, development, and launch of new innovations. Example projects that have been considered so far with the students are weather balloons, human-machine interfaces, solar reflectors, and origami-based mechatronic systems within 10 weeks of internship.

1. Introduction

Engineers are one of the most influential communities in the society who help in improving the quality of life, and providing solutions to many challenging problems [1]. Based on the US Higher Education 2018 indicator ([2] and [3]), students entering engineering degrees at the undergraduate level, master's colleges/universities, and doctorate-granting universities has been increasing. In the UK, the number of students entering engineering education was not grown for decades until late 1990s [4]. However, in July to September 2017, there were 14 million graduates in the UK, following a steady increase over the past decade [5]. Meanwhile, the developing countries such as the BRIC nations (i.e. Brazil, Russia, India and China) producing record numbers of graduate engineers [6] which will overtake the combined GDPs of the G6 countries (US, UK, Germany, Japan, France and Italy) by the year 2040 [7]. A summary of the research findings on engineering education by The Royal Academy of Engineering shows that “the funding and ranking-driven focus on research” in many universities is considered as a constraint in developing innovative learning and teaching [1]. Furthermore, the changing world demands today's students to have some research skills [8], while considering that “The single most desirable attribute in recruiting engineer graduates is their ability to apply theoretical knowledge to real industrial problems” [1]. Other attributes include theoretical understanding, creativity and innovation, team working, technical breadth and business skills. Close collaborations between the industry, communities and the universities in design/make activities can help students to understand the theoretical aspect of the subjects at the university when applying them to real-world applications. Students who are trained to carry out research, particularly in emerging and cutting-edge technologies, are desirable in the industry. Therefore, a solution to prepare a large group of students with the skills required for the 21st century challenges may be found by a research-informed approach which is further enriched through industry, and community service driven goals, for both undergraduate and graduate levels. The applied aspect of the research activity due to the service component can guarantee positive outcomes for both the students and the community, without compromising the University ranking aspiration, which otherwise may be difficult to achieve purely based on traditional engineering curriculum. Defining applied research projects closely in line with the needs of the industry and the real-world applications, and by responding to the needs in the society and service to the communities, can be achieved by the ‘research-informed service-learning’ approach. This also satisfies the diverse need of students ([9], [10]) when the students can select variety of interesting and exciting real-world applied and state-of-the-art projects.

“A broad-based survey on how controls, as an example of a key educational topic in mechatronics field, is taught at undergraduate and graduate degree levels, solicit comments from industry and academia on capabilities and perceived shortcomings of entry-level control engineers, and initiate discussion on how curricula might be improved. A total of 225 IEEE Control Systems Society members responded to the survey questions” [11]. The areas that are recommended to be strengthened to better prepare control engineers, based on this survey, are given in Table 1 [11].

Table 1. The Areas need to be strengthened to better prepare control engineers [11].

	Industry	University		
	(64 Respondents)	All Faculty (109 Respondents)	EE/CE Faculty (73 Respondents)	Non-EE/CE Faculty (36 Respondents)
Hands-on Experience	71.9%	60.6%	50.7%	80.6%
Industry-focused Design	48.4%	49.5%	46.6%	55.6%
Computer Hardware and Software	46.9%	39.5%	35.6%	47.2%
Mathematical Modeling of Dynamic Systems	45.3%	45.0%	46.6%	41.7%
Advanced Methods	28.1%	34.9%	34.3%	36.1%
Basic Methods	28.1%	34.9%	27.4%	50.0%
Other ^a	20.3%	11.0%	22.2%	

As seen in the table, hands-on experience is an important highlight, by both the industry and the University. Practical application of engineering skills, combining theory and experience, and use of other relevant knowledge and skills can include: Understanding of and ability to use relevant materials, equipment, tools, processes, or products, awareness of quality issues and their application to continuous improvement. Graduates must have developed transferable skills, additional to those set out in the other learning outcomes, that will be of value in a wide range of situations, and plan self-learning and improve performance, as the foundation for lifelong learning [12].

“Service-learning is a form of experiential education where learning occurs through a cycle of action and reflection as students work with others through a process of applying what they are learning to community problems, and at the same time, reflecting upon their experience as they seek to achieve real objectives for the community and deeper understanding for themselves” ([13], [14]). “Students, Community Partners, and Instructors are key players in developing effective service-learning activities. Service-learning is connected to course content and is organized around clear learning goals; service-learning provides meaningful service activities which address real community needs as defined by the community; and service-learning provides students opportunities for critical reflection upon their service experiences” ([13], [14]). Service-Learning may be considered as an Active learning activity [15] where students are fully engaged throughout the learning process.

Another benefit of research-led activities is the inherent prevention of plagiarism. Raising awareness of the issue of plagiarism amongst students and develop understanding of academic integrity and authorship has been continuously addressed by the academia [16]. The projects designed based on research-informed approach inherently reduce the plagiarism. This is due to the fact that a research-informed approach is designed based on objectives that are novel in the field of practice which can lead to new research results.

National Academy of Engineering Global Challenge Scholars Program (GCSP) [17], created in 2008, as a vision that is about serving people and society. GCSP is an aspirational vision of what engineering needs to deliver to all people on the planet in the 21st century. In just 15 words, the vision is [17]: “Continuation of life on the planet, making our world more sustainable, secure, healthy, and joyful.” The GCSP was proposed at the inaugural summit on the NAE Grand Challenges for Engineering at Duke University, by the deans of the three founding GCSP schools Duke, Olin and USC. NAE Grand Challenges (GC) committee published its report with the 14 goals (challenges) required to deliver this vision in the coming century. GCSP helps students to

organize their time on exploring results that benefit society through achieving a goal in one of the 14 defined areas. Each year, number of undergraduate and graduate students who successfully complete the GCSP areas in each University will be named National Academy of Engineering (NAE) Grand Challenge Scholars, recognized both by the University and the NAE. The students who are interested in being designated as Grand Challenge Scholars should demonstrate involvement related to a specific Grand Challenge topic in five dimensions [17]:

- Research/Creative experience on a Grand Challenge-like topic
- Multidisciplinary competency: understanding the multidisciplinary of engineering
- Entrepreneurship competency for engineering solution implementation
- Multicultural competency to ensure cultural acceptance of proposed engineering solutions
- Social Consciousness Competency: understanding that the engineering solutions should primarily serve people and society reflecting social consciousness, which are facilitated by the designated coordinators at the Universities.

While the focus on the Grand Challenge should be carried through across the 5 dimensions, only one dimension requires in-depth focus, by a student. A successful Grand Challenges Scholar have flexibility built in so that the student has the choice in choosing the focused dimension. The research-informed service-learning introduced in this paper is in fact geared towards the NAE GCSP vision which can cover all dimensions, where item number 1 is the research component, the mechatronics field of research is a multidisciplinary area which requires experience in cross-discipline fields (satisfies item 2), and requires implementation (item 3), and item 4, and particularly item 5 can be related to service-learning. Therefore, research-informed service-learning can be offered as part of students' senior (capstone) design projects, when the NAE GCSP is not available to the students.

Service-learning can facilitate the integration of applied research into the real-world applications [13]-[28]. This paper promotes research-informed service-learning approach in project-based service-learning by integrating research into service-learning through education. In this paper, examples of research-informed practice for university graduate and undergraduate projects are given, and service-learning is discussed as a powerful tool in education. The paper further discusses case studies of research-informed service-learning as a complementary approach to project-based curriculum and educational activities. Linking University activities to real-world applications and cutting-edge technologies, as a research-informed service-learning project, results in engaging, attractive, and rewarding experience for the students.

2. Research-informed projects for engineering students

In this section, examples of multidisciplinary research-informed projects for graduate and undergraduate engineering programs are introduced, particularly related to the fields of dynamics and mechatronics. The aim of the research-informed activities is to train the students in engineering and preparing them for solving the 21st century engineering problems in industry and contribute positively to the society. Research-informed undergraduate and graduate projects allow students to gain knowledge of cutting-edge technologies while working towards their graduation in their degree programs. Examples of such projects are related to self-powered systems and nature/biologically inspired systems that the students have carried out at Brunel University London, and California State University under supervision of the authors. The projects initiated by the authors as research work, and some of these projects are sponsored by Defence Science and

Technology Laboratory, UK; Royal Academy of Engineering; Brunel Innovation fund; Knowledge Transfer Partnership, Technology Strategy Board (Innovate UK); European Commission FP7; NATO; Edison Energy; and industry. More details about the projects are available in the corresponding references.

The projects associated with energy harvesting and energy independent systems, using electromagnetic (Figure 2, [30]), piezoelectric [29], or electrostatic systems energy conversion mechanisms [38]; and energy independent vehicles using renewable energy sources are considered in the context of the Self-powered Dynamic Systems ([29]-[40]) here.

Solar-powered Unmanned Aerial Vehicles (UAVs) in Figure 1 ([29], [30] and [40]), referred to as Brunel UAVs, are examples of self-sustained energy independent vehicles. These projects are carried out as Master of Engineering degree (MEng) final year group projects at Brunel University London, UK, with groups of six to eight students [41]-[43]. The MEng group projects are final year projects that a group of students from different engineering disciplines, which are typically mechanical, electrical, aerospace, and automotive engineering students, collaborate in design, analysis, building, and testing of an engineering system.

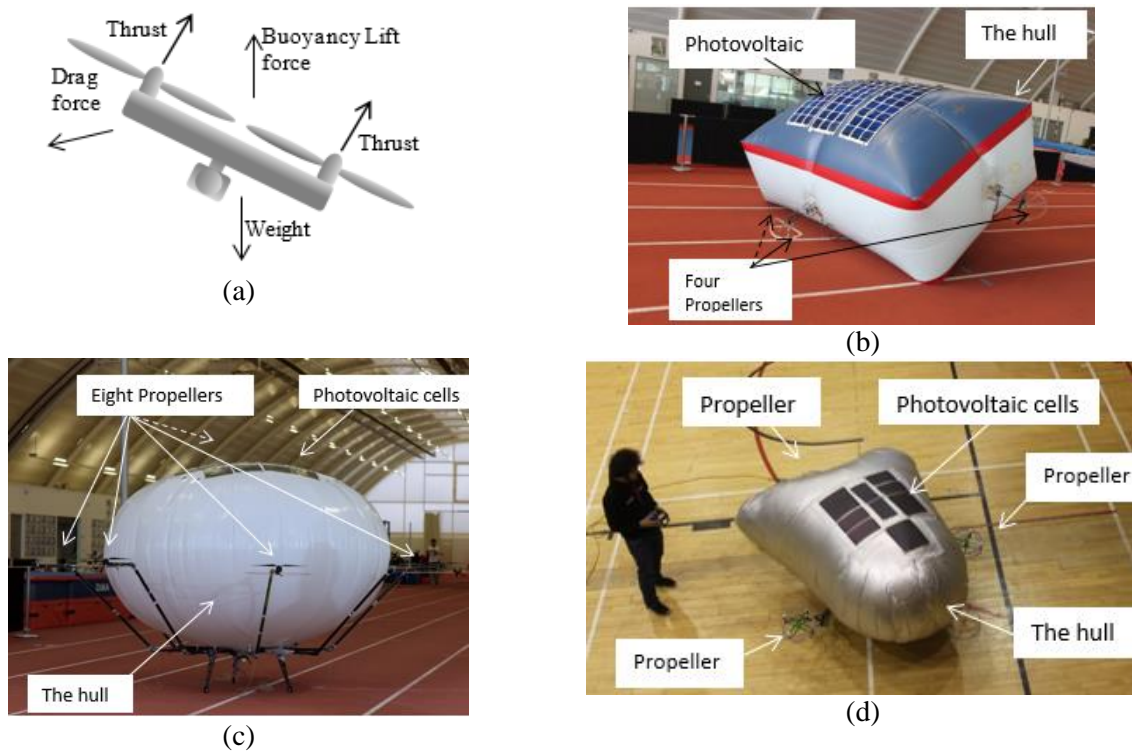


Figure 1. Self-powered solar UAVs [29], [30] and [40], (a) FBD, (b) Quadrotor, (c) Octorotor, (d) Trirotor.

Figure 2, illustrates a self-powered vibration control system consist of: a shaker, for producing the vibration excitations (e.g. base excitations), a spring and a linear actuator/generator in parallel, and a lumped mass as a single degree-of-freedom vibratory system, in a regenerative self-powered scheme ([29]-[30]), with applications such as regenerative vibration control, and self-powered sensors. A piezoelectric energy conversion mechanism is illustrated in Figure 3. In this system,

excitation is due to aeroelastic flutter, with applications in developing self-powered sensors and actuators [29].

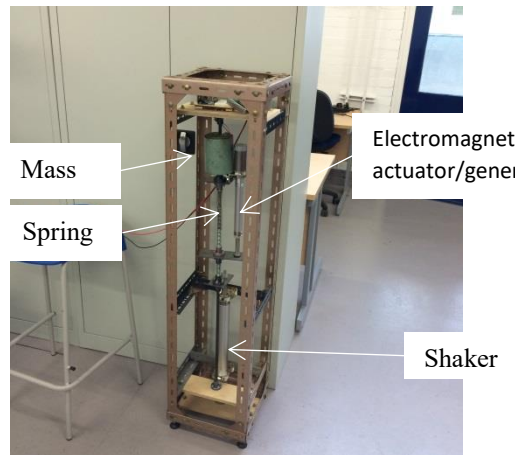


Figure 2. Regenerative self-powered vibration control ([29] and [30]).

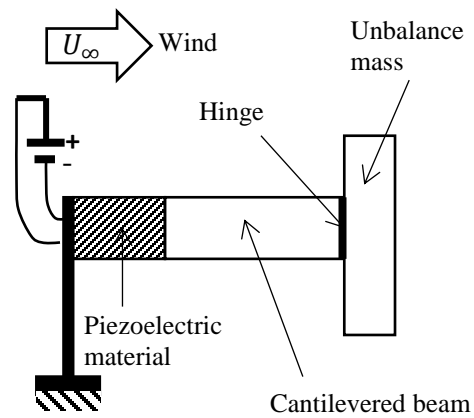
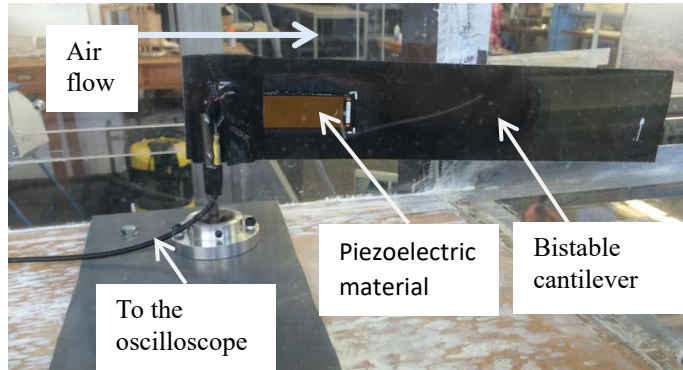
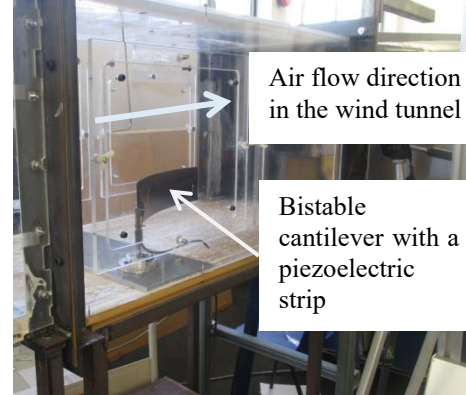


Figure 3. Piezoelectric flutter energy harvesting [29].

The output power of a piezoelectric energy harvesting system can be enhanced using bistable material (Figure 4). The bistable material helps in achieving increased vibration amplitude levels of the cantilever due to the large amplitude of the material snap-through instability. This project has been carried out by a group of M.Sc. students [44], as a requirement of a design course, in the aerospace engineering curriculum at Brunel University London.



(a)



(b)

Figure 4. Piezoelectric flutter energy harvesting using bistable material [29]; (a) side view; (b) bistable material large deflection due to the wind load.

On biomimetics, the students have contributed to various experimental research work ([29] and [31]) such as insect-inspired flapping wings (Figure 5(a) and Figure 5(b)), in fulfillment of their M.S. group project requirements, with a group of six aerospace engineering students [45] at Brunel University London.

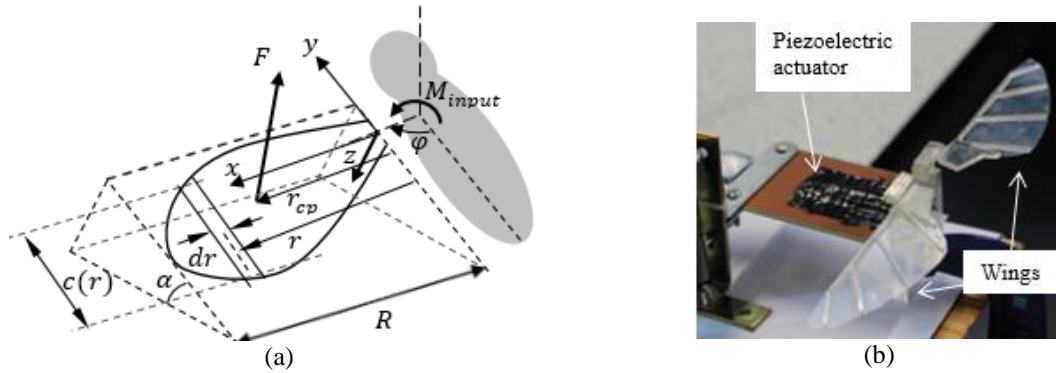


Figure 5. Insect-inspired flapping wings [29]; (a) geometry of a wing model, (b) an insect-inspired wing.

The bird-inspired wings design and analysis [29] in Figure 6(a) to Figure 6 (d), carried out by four M.S. students as a group project [47], and one M.S. student as an individual final year project [46]. The fish schooling inspired piezoelectric energy harvesting project in Figure 7(a) to Figure 7 (b) is carried out as individual BEng and M.Sc. student projects.

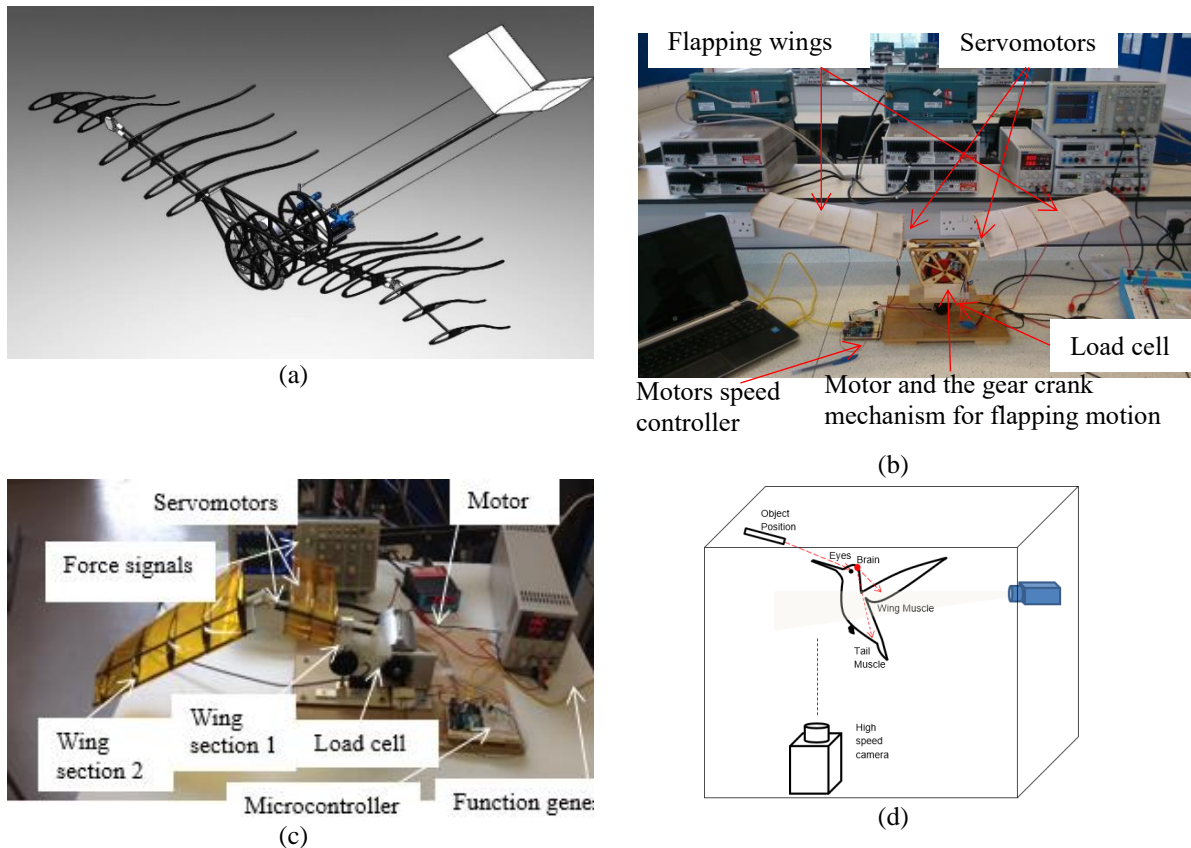


Figure 6. Bird-inspired flapping wings [29]; (a) model of a bird-inspired flying vehicle, (b) a two DOF wing, (c) a three DOF wing, (d) bio-inspired flight control.

A scaled Vertical Axis Wind Turbine (VAWT) farm inspired by fish schooling, with the objective of achieving increased power density, carried out by six MEng students at Brunel University London (Figure 7(a), (c), and (d)) [48]. Figure 7(b) shows a similar concept of the fish schooling inspired approach (Figure 7(a)) applied to a system of piezoelectric flutter energy

harvesters, carried out by various individual BEng students at the University of Hertfordshire. Figure 8 illustrates jellyfish-inspired pulsing jet [29], as an individual M.Sc. final year project, and also as a group project by six M.Sc. students at Brunel University London [49], as part of their aerospace design course requirements. The details regarding the projects can be found in the corresponding references.

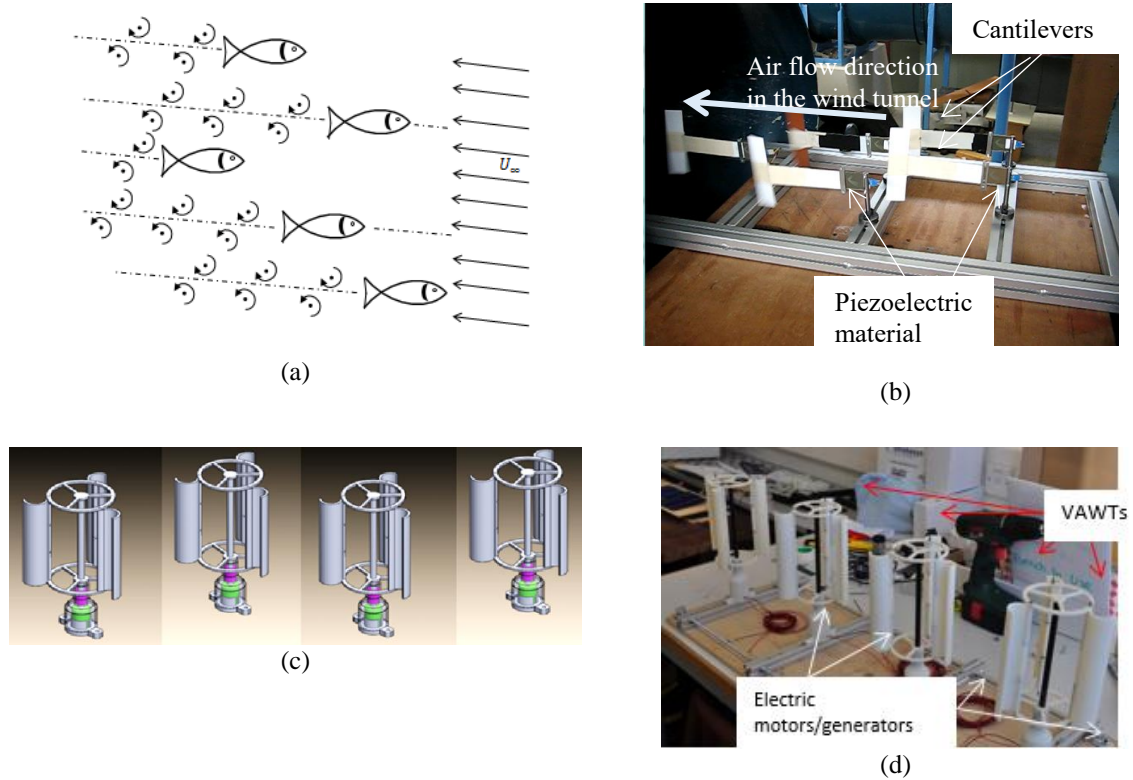


Figure 7. Fish schooling-inspired wind energy [29] (a) generated vortices by the school of fish, (b) piezoelectric energy harvesting, (c) A vertical axis wind turbine (VAWT) design, (d) Scaled model of a VAWT farm for experimental investigation of power density

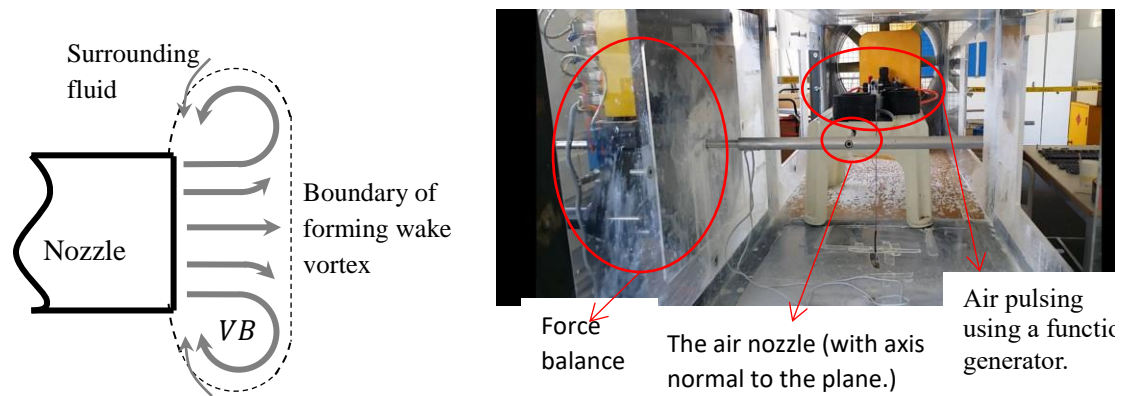


Figure 8. Jellyfish-inspired jet propulsion [29], (a) Fluid mechanics principle, (b) Experimental setup.

Multi-agent robotic, and quantum entanglement and cryptography research has been recently carried out by the authors, associated with their collaborative research on networked dynamical

systems, nature-inspired Psi precognition [50], quantum entanglement and networks ([51], [52]), and experimental investigation of quantum entanglement and cryptography in robotics ([52], [53]). This is an ongoing research work which is now being introduced as undergraduate and graduate projects at California State Polytechnic University, Pomona, and offered to the students as original research-informed projects. Further, it is planned to be applied to real practical applications, in collaboration with Jet Propulsion Laboratory (JPL), and being incorporated in a service attempt.

Examples of quantum multi-robotic research by the authors are given below. A Quantum Entanglement (QE) inspired technique is proposed to complement multi (autonomous) vehicles/agents/robots/unmanned systems [51] operation while the communication between the vehicles is disrupted or lost due to cyber-physical attacks or a fault in the system. A QE-inspired algorithm [54] is used to demonstrate the behavior of two mobile autonomous systems in finding each other (Figure 9(a)), and two mobile agents pushing an object (Figure 9(b)), after the communication is lost between the collaborative systems. The simulation results are promising as shown in Figure 9 [51].

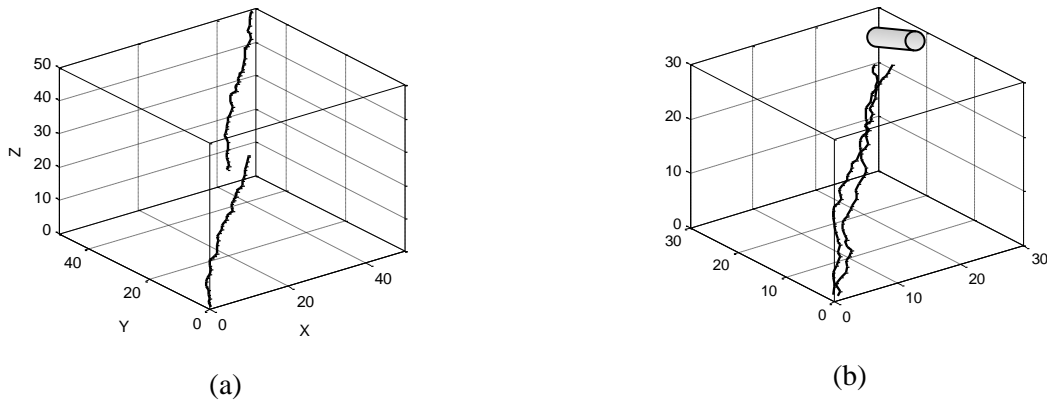


Figure 9. QE-inspired approach; (a) two vehicles/robots (one at (0,0,0), and one at (50,50,50) at time=0) finding each other (b) Quantum cooperation of two vehicles/robots in pushing an object [51].

A Quantum Entanglement (QE) approach associated with collaborative multi-agent autonomous unmanned systems has been investigated in a quantum network framework. Simulation results for 25 autonomous mobile systems (e.g. UAVs) are shown in Figure 10(a) and (b). In Figure 10, the starting locations of each vehicle are shown by circles, and final positions of the autonomous vehicles are shown by the filled squares. The trajectories of the vehicles are shown from each initial location to the final position. An example of graph Laplacian of the network is presented Figure 10, when only neighbor nodes (e.g. UAVs) are communicating in Figure 10(a), versus all nodes communicating in Figure 10(b). The communication links between the vehicles are shown at the final locations of the vehicles in Figure 10.

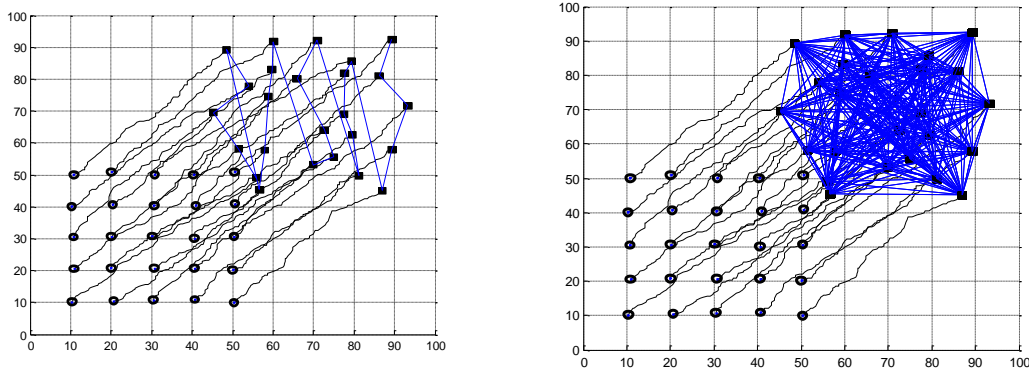


Figure 10. The graph Laplacian representation of 25 networked UAVs (a) Only neighbor UAVs are communicating (b) All nodes communicating; horizontal and vertical axes represent x and y coordinates.

Interference experiments which exploit the quantum nature of the light has been realized for experimental quantum entanglement. The experiments use parametric down-conversion to generate pairs of correlated photons. Single photons are generated by spontaneous parametric down conversion, where a crystal of beta-bariumborate (BBO) is pumped by the output of a laser diode, producing photon pairs. Light enters the interferometer and polarized (vertically and horizontally) when passing through half-wave plates. The beam then encounters a beam displacing prism (BDP), and detected by single photon counters (e.g. [55] to [60]). Such experiments has been proposed by the authors for collaborative robotic communication applications [52], and the experiment is currently under investigation for multi-mobile autonomous systems [53] (Figure 11).

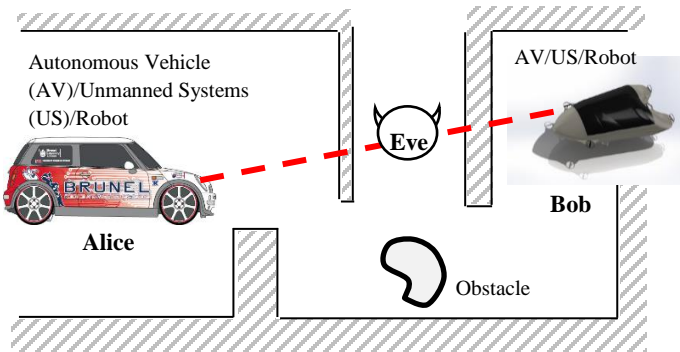


Figure 11. Quantum entanglement of autonomous mobile systems [53].

Quantum cryptography with applications to autonomous multi-robot communications is novel project under investigation by the authors [50], which is also being introduced as student projects at California State Polytechnic University, Pomona, and Brunel University London, in collaboration with JPL. Figure 12 shows the experimental set-up where “Alice”, located on the mobile robot in the figure, sends laser photon pulses through half-wave polarizing plates, and “Bob” robot receives the polarized photons by its detectors. The combinations of -45° , 0° , 45° , and 90° polarized photon pulses sent from Alice, and the 0° , 45° polarizations passing through Bob’s half-wave, which is then passed or reflected to Bob’s two detectors using a non-polarizing beamsplitter cube, guarantee secure communications.

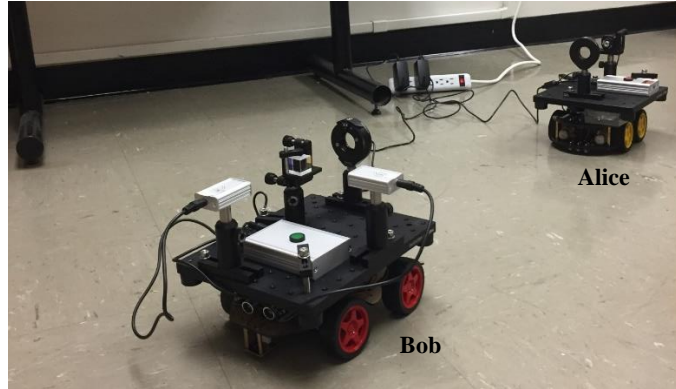


Figure 12. Quantum cryptography for autonomous multi-robot communications [53].

On the topic of simulation with uncertainty we propose the application of a unified framework in analysis as a generalized approach. Optimal Uncertainty Quantification (OUQ) [61] is a technique which takes into account uncertainty measures with optimal bounds, and incomplete information about the system and input excitations while providing an optimized solution for a problem ([61], [62]). OUQ for self-powered and nature-inspired systems has been investigated by the authors (e.g. [30], [31], and [40]) as a powerful technique, where the formulation is aimed to develop a well-defined optimization problem corresponding to extremizing the probabilities of system failure. The failure in a dynamic system may refer to the system not being able to provide a satisfactory response. Performing an advanced mathematical analysis, such as OUQ, can be too challenging for the students, particularly at undergraduate level. In such cases the faculty supervisors undertake the task.

The students, who carried out their University project (introduced in this paper), have received various awards as the result of their work (e.g. Figure 1, Figure 8) from Airbus, Bosch and other companies ([63] examples of student awards). In all the above projects, the initial research work including literature review, feasibility study, and proof of concept have been carried out by the faculty supervisor (e.g. [52], [53]), prior to introducing the topics to the students. Therefore, the students with little research experience, who are not in fact expected to perform advanced engineering research, can manage the projects successfully, while under supervision of the (faculty) advisor. In a research-led project, students are generally very successful in the hands-on work, development, and implementation of the project (e.g. in producing the experimental set-up, or building a prototype). As the result of the research projects, various articles are produced by the faculty, after extensive analytical and experimental work (e.g. [30]-[36], [39], [40]), carried out by the faculty supervisors. Although the results in the papers are produced and the articles are written by the faculty in the above mentioned research-led examples, in some cases, the students have been included as co-authors in the publications, depending on their level of involvement in the project, and in some cases written by the students (e.g. as a result of M.Sc. Projects) themselves [37].

3. Service-Learning

The partnerships between a University and community organizations can provide many opportunities and benefit for all those involved. “Students can enrich their academic learning and civic ethic; faculty can find community partners provide excellent co-educators and the partnerships can invigorate their teaching and research; agencies can access enormous resources

to address their missions and goals, and; community members gain through services that might not otherwise be available” [13]. “It is important to carefully consider various aspects of the partnership before embarking on a service-learning project. The following issues and recommendations are taken or adapted from service-learning research and stakeholder input” [14]. The following notes are compiled from the Service-Learning workshops and seminars at California State University, Fresno ([13] and [14]), and some adopted from the corresponding references (e.g. [18]-[27]) as cited below.

In a service-learning activity, Community Partner’s Goals, Faculty Member’s Goals, Student’s Goals should be clearly identified ([13] and [14]) (see Appendix A for details). There are challenges in university/community partnerships ([13] and [14]). “Universities have a very unique cultures, styles, communication patterns, schedules and visions for working in and with the community. These characteristics can be very different from the potential partners in the community. Similarly, nonprofits and other service-learning partners have distinct characteristics that often present challenges to the university (Details on how to discuss and resolve the differences is available in Appendix B).

Key concepts for successful partnerships ([13] and [14]) include engagement of community partners and students, personal interactions, faculty members visit to the community based organization, shared ownership and collaboration through ongoing interaction and communication, and defined community needs (see Appendix C for more details).

In order to design a successful partnership and building collaborative relationships, partners in service-learning should have a shared vision and clearly articulated values, tangible incentives for partners (acknowledging self-interests as well as shared interests), a sense value for the bonds already formed among people, means for allowing frequent and open communication on issues of shared responsibilities, an appreciation for the fact that these partnerships are multi-dimensional, and consideration of the unique assets of each partner ([13] and [14], [26]) (see Appendix D for details).

Sustainable partnerships should be looked upon like a good long term friendship for ongoing, and growing collaborations that lasts beyond a single activity or course. Over time, the relationship provides a means to improve the quality of service-learning. This will allow for better quality experiences for students, with richer learning and service outcomes ([13] and [14]) (see Appendix E for details). Campus and community should build formal, long-term relationships founded on collaboration and the clear articulation of needs, capacities, responsibilities and expectations ([27], [25], Details are available in Appendix F, and Appendix G for the community collaboration planner).

4. Research-Informed Service-Learning

The undergraduate and graduate project based engineering research-informed approach was introduced in Section 2. Service-learning partnership was presented as a powerful tool in enriching education and research, in Section 3. This section bring the two together by introducing case studies of research-informed service-learning (Figure 13) as a complementary approach in research and education.

As a practical example of the service-learning paradigm, the Innovation to Flight (I2F) Student Program at the Jet Propulsion Laboratory uses a ‘start-up’ approach to “pitch” new ideas for innovative technologies, methods and systems to be infused into future missions. The I2F program has been active in the last few years with the intent of promoting the adoption of a complementary

strategy and culture that encourages and employs rapid innovation to flight paths for certain well-selected, directed concepts and technologies which would have high benefits through exploiting this approach. More specifically, the goals of I2F are to: A) Enhance and develop a core capability that embodies the practices of rapid and lean/agile development methodologies. B) Create an environment, processes, and culture of nurturing rapid innovation. C) Provide rapid and affordable access to space for innovators leveraging advancements in launch technology and ridesharing capabilities, improving innovation Technology Readiness Levels (TRL) and expanding mission possibilities. D) Train, inspire, and motivate the next generation of aerospace engineers (mostly student interns visiting JPL during summer sessions) through immersion into flight by rapid design, development, and launch of new innovations. Example projects that have been considered so far with the students are weather balloons, humanmachine interfaces, solar reflectors, and origami-based mechatronic systems. For each project, ranking criteria were used to facilitate the innovation, including degree of novelty, plan feasibility, exciting factor, importance to I2F, and likelihood of project success within 10 weeks of internship.

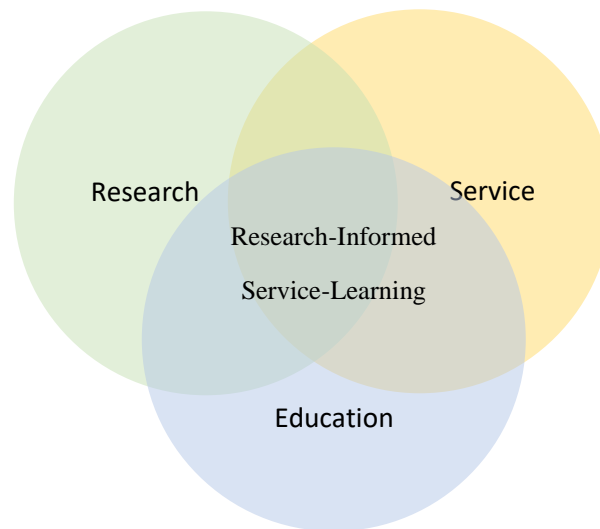


Figure 13. Research-informed service-learning

A research-informed service-learning project carried out at California State Polytechnic University, Pomona, in collaboration with the Police department. Three students are working on their capstone design group project with the service learning component goal being to help the police department to monitor traffic and provide situation awareness using drones (Figure 14) at the University.

The faculty member has introduced the project and has facilitated the initial work for the students. The research component of this project is to overcome the flight time limitation of current electric multirotor technology by designing a novel solar powered UAV (similar to the Brunel UAVs introduced in the research-informed section). This is an ongoing project and the students are currently demonstrating the capabilities of a commercial drone, with an onboard camera, for monitoring applications (Figure 14). Due to the applied real-world and cutting edge research aspects, as well as the opportunity to provide service to the community, the students are very engaged in the project, which will count very positively towards their graduations, and prepare them for their future careers in mechatronics engineering.



Figure 14. The research-informed service-learning project, on traffic monitoring and situation awareness, in collaboration between the Police Department, students, and the faculty supervisor.

An example of a service-learning practice, which includes detailed information about the initial proposal, benefits for the partners and the students, and discussions is provided in Appendix H.

Conclusions

The authors are promoting research-informed service-learning projects as an educational tool to prepare and train students for the 21st century engineering challenges. Examples of research-informed projects were introduced, and service learning approach was discussed. Case studies of a research-informed service-learning was presented including the University and Police partnership as an engaging and rewarding project for the students, and the Innovation to Flight (I2F) Student Program at the Jet Propulsion Laboratory to Enhance and develop a core capability, nurturing rapid innovation, and train, inspire, and motivate the next generation of engineers. Engagement with industrial projects also enriches the curriculum, giving students the opportunity to practice professionalism within their projects and gain a greater appreciation of business practice. Furthermore, merging applied research and service in traditional engineering curriculum, as well as new course developments (e.g. in mechatronics, robotics, autonomous systems related topics), is suggested as a future work for more rewarding student experience, which also benefits faculty research, and the society.

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Appendix A

The service-learning goals ([13] and [14]):

“Consider various stakeholder’s perspectives on the most desirable outcomes of a service-learning partnership. Where do the different participant’s goals conflict and how can those conflicts be minimized or avoided? If goals do differ, consider ways to provide for differing objectives. Where do the goals converge and how can service-learning be used to meet those common goals?

- Community Partner’s Goals: What are they? How can the service-learning program support those goals? What skills, Community strengths and weaknesses does the co-educator bring to the partnership?
- Faculty Member’s Goals: What are they? Research? Teaching? How will these goals be supported by this collaboration? What skills, strengths and weaknesses does the faculty member bring to the collaboration?
- Student’s Goals: What are they? How does service-learning support those goals? What skills, strengths and weaknesses does the student bring to the collaboration?”

Appendix B

The challenges in university/community partnerships for service-learning? ([13] and [14])

“Universities have a very unique cultures, styles, communication patterns, schedules and visions for working in and with the community. These characteristics can be very different from the potential partners in the community. Similarly, nonprofits and other service-learning partners have distinct characteristics that often present challenges to the university. Consider and be sensitive to some of the following when developing your partnerships.

- What are the differences each party brings to building relationships, negotiating conflict/differences, listening, and use of language?
- How can trust best be established between partners when there may be different norms for ethical conduct, respect, genuineness, and commitment to the issue/agency/clientele?
- How can communication be maximized and what issues need to be considered? Is communication between partners inclusive of various perspectives? Are communication methods equally effective and available to all partners? (i.e. Do all parties use email?) How is feedback gained and utilized? What are the politics that need to be considered within the different organizations?

- Do partners hold equal power and/or are they equally empowered through the service-learning relationship? Is there shared control and leadership? Are issues of social justice considered? Similar to communication, are all parties “voices” heard throughout the process? What challenges arise out of availability or distribution of money and other resources?
- Is there shared vision for producing and sustaining change?
- What risks are seen? Which are taken? Who benefits?
- How can community partners contribute to academia and how can academia meaningfully contribute to the community?
- What issues of time and scheduling might impact the partnership? How much does each partner have, take and give? What conflicts arise between the academic schedule and calendar and that of the community partner?
- What are the rules and norms for confidentiality? Is there a need for informed consent?
- What issues might arise out of reports and publications? Is there going to be shared credit and recognition?”

Appendix C

The key concepts for successful partnerships? ([13] and [14])

- Engagement of community partners (and students) should be up front, during the design of projects. One of the most important points to remember is that community partners are neither the university’s laboratory nor the passive recipient of a university’s expertise and generosity. Community partners are just that – partners. As partners, they have resources and knowledge to bring to the collaborative.
- Personal interaction is important. Whenever possible, faculty members should visit the community based organization, participate in service activities and engage community partners in similar fashion within the classroom. There is a reciprocal and mutual benefit when faculty members become servers and agency partners become co-educators.
- Cultivate shared ownership and collaboration through ongoing interaction and communication. Once the planning has ended and the service has started, the relationship has only begun.
- Community partners and those they serve should be the ones who define community need. Identify those needs early on and be sure that they mesh with the academic needs/purpose of the course.
- Plan community impact to facilitate real change through service-learning.
- Don’t forget about the students! Work with students to help define and clarify their role in service-learning. Create service tasks to meet student needs and take maximum advantage of their skills. Always provide appropriate orientation to the service-learning assignment and to the agency, train the student as needed, and provide adequate supervision and continued support.
- Celebrate the partnership and the results that come from it. Recognize and demonstrate appreciation for the contributions that all stakeholders make to the service-learning experience.

Appendix D

Design a Successful Partnership and Build Collaborative Relationships ([13] and [14], [26])

“Do the partners in your service-learning project have:

- A shared vision and clearly articulated values?
- Tangible incentives for partners, acknowledging self-interests as well as shared interests?
- A sense value for the bonds already formed among people, while creating new networks of relationships that deepen over time and shared experience?
- Means for allowing frequent and open communication on issues of shared responsibilities, risks and rewards, and accountability.
- An appreciation for the fact that these partnerships are multi-dimensional, involving multiple sectors addressing a complex problem?

- Consideration for the unique assets of each partner for comprehensive problem-solving?”

Appendix E

Developing sustainable partnerships. ([13] and [14])

“Whenever possible, partnerships should be looked upon like a good friendship. They are not short-term relationships that last a semester or two. They are ongoing, growing collaborations that should be designed to last beyond a single activity or course. Over time, the relationship provides a means to improve the quality of service-learning. This will allow for better quality experiences for students, with richer learning and service outcomes.

Develop a foundation to expand the program on campus and within the community. Maintain momentum for the partnership by always looking beyond the current project.

Random thoughts from the Community Perspective.

Prepare a brief summary of the course for the community agency that would include at least the following:

- A description of the course and how service-learning is used to support the course objectives.
- The number of hours the student is expected to participate in the service-learning experience.
- A list and samples of any paperwork or forms the student is required to have completed by the agency.
- The instructor’s name and contact information.

In terms of work schedule, the following points are important:

- Depending on agency needs, ten hours of service would be the absolute minimum. Twenty or more hours would be ideal.
- Have students notify the agency as early as possible (24 hours or more in advance if possible) if they are not able to be present during their regular hours.
- Encourage students to be consistent in the hours they work.
- Encourage students to be prepared and on-time for each of their service-learning sessions.

Let the students and the agency representatives know what process to follow if problems arise with the quality of work, experience or supervision arise.

If possible, visit the service site to get a sense of the students’ service-learning experience.

Consider gathering feedback from the students at about the midpoint of their service-learning experience. This feedback can provide some helpful analysis of the students’ experience and lead to adjustments in the experience if necessary.

Give the community agency the opportunity to provide some evaluation of the students’ work at the agency.

Have the students develop a summary of their experience that can be shared with the community agency.

This written summary might include:

- What the student learned from the service-learning experience.
- The strengths and weaknesses of the experience
- The ways in which the service-learning experience related to the course material.
- The overall benefits of the service-learning experience for the student.

Having the students provide some form of “thank you” to the agency at the end of the service-learning experience is helpful and greatly appreciated.

In general, ask the students to remember the following things about the service agency:

- They have a “way of doing things” and students should respect that.
- The people they serve have assets as well as needs.
- The people served are influenced by family, culture, status, tradition and more.
- Agencies are looking for volunteers who are: Reliable, Ethical, Attentive, Caring, and Helpful.”

Appendix F

Campus & Community Partnership Principles [27]

“Partnerships with community agencies are formal, long-term relationships founded on collaboration and the clear articulation of needs, capacities, responsibilities and expectations. Regular communication and evaluation and equal say in the design and implementation of projects are its defining features. Most campus [people] agree that partnerships with community agencies are more valuable (and labor intensive) than simple placement arrangements. Partnerships entail making a commitment to the agency, relinquishing control over aspects of the program and accepting new responsibilities.”[25]

- 1) Partners have agreed upon mission, values, goals and measurable outcomes for the partnership.
- 2) The relationship between partners is characterized by mutual trust, respect, genuineness and commitment.
- 3) The partnership builds upon identified strengths and assets, but also addresses areas that need improvement.
- 4) The partnership balances power among partners and enables resources among partners to be shared.
- 5) There is a clear, open and accessible communication between partners, making it an on-going priority to listen to each need, develop a common language, and validate/clarify the meaning of terms.
- 6) Roles, norms, and processes for the partnership are established with the input and agreement of all partners.
- 7) There is feedback to, among and from all stakeholders in the partnership, with the goal of continuously improving the partnership and its outcomes.
- 8) Partners share credit for the partnership’s accomplishments.
- 9) Partnerships take time to develop and evolve over time.”

Appendix G

“COMMUNITY COLLABORATION PLANNER

1. Briefly describe your organization: mission, main interest, population served, organizational structure, and resources/budget that might be relevant.
2. What do you see as the potential benefit for the community from students performing these service activities? What are the most important lessons your organization can teach college students?
3. List three service outcomes (representative activities that you would like students to perform) at your organization and describe them to the students and faculty members.

Faculty Members and Students

4. Describe the course in which community-service learning will be used.
5. List your top three student learning outcomes (the three most important things you want to learn or have your students learn during the service learning experience) and describe them to your community partner.

Both Partners

6. Find at least three intersections where the faculty and student goals (number 5) and the community partner goals (number 2) can coalesce. Keep talking and negotiating until this is accomplished.

Logistics: Work together to arrive at decisions regarding all of the following:

1. How long will the service component of the class last? Start date_____ End date_____
2. How many students will go to this site?
3. How many times a week will they come to the site?
4. How many total hours will be required of each student?
5. Are there transportation or parking problems?
6. Who will conduct student orientation?
7. Will orientation be in class or on site?
8. What “ice-breakers” will be used to introduce students to their on-site clients?

9. Who will be the on-site supervisor?
10. What are the on-site check-in and check-out procedures?
11. How will students be evaluated?
12. What indicators or outcome measure will be used?
13. How will communication between the faculty members, students and community partner be maintained throughout the semester. Exchange phone numbers.
14. What is the plan for closure and recognition of participants?
15. Is any special training of students necessary? Who will provide it? Can faculty member and the community partner share the special training?

Community Partner Information Appendix

Community Agency Name: _____

Federal ID Tax Exempt Status Number: _____

(Having this information helps to ensure that the agency is a recognized “nonprofit” organization. If it is a government entity, or are some other form of community organization, clarify that at the outset of the conversation.)

Agency Address: _____

Where Will Students Provide Service: (If different than address above): _____

Phone Number(s): _____

Website: _____

Primary/Secondary Contact(s), Email and Cell Number (if appropriate): _____

Summary of Agency’s Mission/Purpose: _____

Population Served: _____

Greatest Volunteer/Service Resources Needed By Agency/Constituents, as identified by the Agency: _____

Requirements for Volunteers: (May include fingerprint screening, attending training/orientation, language skills, TB test, etc. How much time does the agency need to complete screening before students can start?)

Minimum Hours of Service Required By Agency of Each Student: _____

Anticipated/Desired Work Schedule for Students: (Ideally, service should be conducted across the semester, not in just one or two visits. _____

To the agency’s or faculty member’s knowledge, does this agency currently have a formal “Service-Learning Agreement” with California State University, Fresno?

Yes _____ No _____ Unsure _____

Faculty/Course Information

Course Instructor’s Name: _____

Address: _____

Phone Number(s): _____

Email Address: _____

Course Title/Number: _____

Course Schedule: (Semester/Days/Hours typically offered): _____

Brief Course Description (consult catalogue description): _____

Course Outcomes Most Related to Service-Learning: _____

How This Outcome can be Met Through Service _____

Minimum Hours of Service Required of Each Student: _____

Mutually Identified Opportunities/Benefits/Challenges

Potential Benefits of Service to the Community Organization and Population Served: _____

Potential Risks Factors Students Should Be Aware Of: _____

Necessary Orientation and Training Components: (Especially as related to mitigating risks described above, and to help students provide the highest quality service that will lead to desired service and learning

outcomes. Also, who will be in charge of orientation and training and when/where will it take place?)_____

Other Important Questions for Discussion/Consideration

16. Assets-Based Community Development:

- a. What assets does your partner possess and how can you help them build upon or use those assets (to help them)?
 - b. What assets does your partner have that could enhance your students' learning (expertise, access to a certain population, ties to community, etc.)?
 - c. What assets do you have that you can share with the partner (affiliation with the university, ability to conduct research, etc.)?
17. Make sure all parties understand what service-learning is (enhanced academic learning, meaningful service and purposeful civic learning) and how it differs from volunteering, internships, etc. It is likely that the partner may have only had experience with interns or volunteers, so it is important to make this distinction.
18. Discuss your expectations of how the course's academic content will be enhanced through this experience (using the learning outcomes you listed above). Your partner may have ideas on what project the student could do to meet these goals.
19. Agree on the project (don't assume the project as you have formulated it is best – ask the partners for suggestions) and the basic nuts and bolts of who is responsible for what, who *does* what and when.
20. Evaluate the project before, during and after activities take place. Is there a way to enhance the learning experience of the students? (The partner may have good ideas you haven't considered)
21. Who will be the on-site supervisor (if different from primary contact)?
22. How will students be evaluated by instructor and by community partner? How, if at all, will the agency evaluation of the student be factored into the assignment/final grade?
23. Will the student be asked to evaluate the agency and/or site supervisor? (If so, share a sample of that evaluation format prior to the start of the semester.)
24. How will communication between the faculty member(s), students and community partner be maintained throughout the semester? What are the best ways to communicate between parties? (Have some agreed upon timelines and process for check-ins and summative communication at the end of the semester. Also, discuss under what circumstances the instructor wishes to be informed if students are performing unsatisfactorily or if other situations arise that impact the agency, constituents served, or overall purpose/goals of the project.)
25. Is there a plan for closure and recognition of participants?

Additional Topics as Identified by You and Your Community Partner:

Service-Learning Partnership Planner, California State University, Fresno, 2014

For You (or your team) to Consider After This Initial Meeting:

1. Is the project you have formulated a high-quality SL project that balances purposeful Civic Learning, Increases Academic Learning and provides a Meaningful Service? If "yes," articulate how your project addresses each of these components. If "no," list how you could alter the project so that it adequately addresses these components:
2. Is the service planned linked to the curriculum and outcomes strong and clear?
3. Is there a way to enhance the learning experience of the students? How so?
4. Evaluate the potential partnership:
 - a. Benefits for all parties (students, community and faculty)
 - b. Challenges/concerns
 - c. Possible solutions to the challenges/concerns
 - d. Follow-up questions for the partner
 - e. What else do you need to know to proceed?
 - f. Other possible partners

5. Other notes on the initial meeting:
6. What next? Make a “to do” list

SL Project Design Worksheet

1. List what you want the students to know/learn/embrace IN YOUR DISCIPLINE (not necessarily your class).
2. List the BIG IDEAS you want your students to remember from YOUR classes in 10-20 years.
3. Which, from #1 and #2, might a SL project address (better than traditional instruction)? (you may end up generating a project idea for a class you don’t teach!)
4. Of the classes YOU teach, which can best address one of these big ideas through SL?
5. What are the things you want your students to know or have done or have experienced by the end of THIS course (don’t look at current outcomes yet!)
6. What is the catalogue description for this course?
7. Now list (or paste) the Learning Outcomes for your course below.
8. Generate new learning outcomes for the syllabus based on this exercise if applicable.
9.
 - a. Which one(s) could be met by SL:
 - b. Which one(s) might be BETTER met by SL than in a traditional manner:
10. Which type of agency fits best?
11. What questions would be good to ask these agencies?”

Appendix H

An example of a Service-Learning proposal and corresponding discussions developed at California State University, Fresno.

Proposal: This is a proposal on the applications of Unmanned Aerial Vehicles (UAVs) for providing service to the community. Application of solar energy in developing an energy independent system is the research aspect of the project.

Interest in service-learning and any previous experiences in the service-learning field:

Interest:

- Teaching the engineering background related to Unmanned Autonomous Systems and Robotics.
- Provide services using UAVs for various applications such as security (on campus).
- Research on how to develop an energy independent vehicle using solar energy.

Experience example:

Designed a student competition called ‘Drone Egg Race’, with the objectives of students learning about dynamics, mechatronics and control of drones while participating in a fun event. This is the link to the ‘Drone Egg Race’ instruction and the results:

The link below shows what I developed in my previous University for our fresher's induction week:
<https://www.youtube.com/watch?v=G2MliK2AZWk>

The link below shows what the students did: <https://www.youtube.com/watch?v=VGwq9O55V8g>

Course(s) which you believe may be appropriate for a service-learning component. Include the frequency the course(s) are offered each year and the number of students enrolled annually in those section(s).

Instrumentation and Measurement course. Usually about 50 students enroll in the 3 sections of this course. This course is very relevant to robotics, instrumentation, UAVs, energy systems, and measurement in general.

Service Learning - course/project

Grading Weights Lab Assignments 30%

Midterm exam 2 x 20%

Project 30% (related to SL)

Course Goals:

To be familiar with electro-mechanical systems and their applications.

Student Outcomes of Bachelor of Science in Mechanical Engineering:

- a. An ability to apply knowledge of mathematics, science, and engineering.
- b. An ability to design and conduct experiments, as well as to analyze and interpret data.
- c. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- d. An ability to function on multidisciplinary teams
- e. An ability to identify, formulate, and solve engineering problems.
- f. An understanding of professional and ethical responsibility.
- g. An ability to communicate effectively.
- h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
- i. A recognition of the need for, and an ability to engage in life-long learning.
- j. A knowledge of contemporary issues.
- k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Primary Learning Outcomes:

Upon completion of this course, students will be able to:

1. Understand applications and limitations of common sensors and actuators used in modern engineering systems with sufficient depth to be able to select an appropriate sensor or actuator for a specified application.
2. Program and use a microcontroller to solve a specified engineering problem.
3. Build an electronic circuit given a circuit diagram / schematic and the required components.
4. Design and implement an integrated electro-mechanical system using the components and techniques covered in the course.
5. Work with a partner in designing a mechatronics system.

REFLECTION:

1. List what you want your students to pay attention to during the S-L project (pre-reflection) - Your BIG IDEA in the winter break assignment and your outcomes may inform these:

The students collect data and understand how drones work and benefit the society.

2. List questions that could guide your students to make connections between the project and course concepts, theories or topics, in a way will enhance their education (enhanced academic content) - think what topics you will cover in class and what you want them to learn from the project):

Measure the energy consumption during the flight for different duty cycles.

When using drones for security, surveillance, or monitoring, are you collecting enough required information? What are the flight restrictions?

3. List questions that could guide your students to examine the value of applying their knowledge to serve (civic education) - think of WHY you are having them do SL, WHY you are placing them where you are... in a CBO.. what skills they can take away and apply in their life and career:

Learning engineering with real-world applications. The students should be able to apply the theory that they learn in their engineering courses to real practical applications.

4. List questions that could guide your students to gain new perspectives, insights and increase empathy (civic education):

The questions can include practical applications, for example how you can make a community to be safer place by using drones for security, or applying them for agriculture for plant monitoring, delivery, or telehealth, aerial robotics, maintenance, etc.

5. Take my comments on your Winter Break Assignment and what you formulated (best outcomes, description of project), the Bloom's Taxonomy sheet (words to use in your outcomes) and the S Designation Rubric (things to include in your syllabus), and try and incorporate these into your syllabus.

SERVICE-LEARNING PARTNERSHIP PLANNER

Partnerships between a university and community benefit organizations can provide enormous benefits for all those involved. Unfortunately, partnerships that are not well-planned or nurtured can often provide less than desirable outcomes. For this reason, it is extremely important to carefully consider various aspects of the partnership before embarking on a service-learning project. The questions on this form are designed to help guide initial conversations about a service-learning partnership and allow for mutually beneficial outcomes for community benefit organizations, faculty members and students.

Remember, you are not the expert when it comes to what your partner's needs. Also, they will likely have ideas you have not considered regarding your students' educational experience. Respect that your partner has experience and expertise that can enhance your students' education and probably has ideas and perspectives regarding their mission and who they serve that you have not considered. Additionally, it is often helpful to consider the ASSETS your partner has, and the ASSETS you can share

SL Seminar case study example

1. List what you want the students to know/learn/embrace IN YOUR DISCIPLINE (not necessarily your class).

Learn about dynamic systems in general. A dynamic system can be any system that moves. Analysis of the motion of the system including the forces and energy is the interest of the dynamic system area. A dynamic system can be a car, aircraft, machinery, etc.

2. List the BIG IDEAS you want your students to remember from your classes in 10 -20 years?
Students to learning about 'self-powered dynamic systems'. Renewable energy applications and energy harvesting techniques for dynamic systems. For example developing energy independent solar powered aerial vehicles (solar powered drones).

3. Which, from #1 and #2, might a SL project address (better than traditional instruction)? (you may end up generating a project idea for a class you don't teach!)

Developing solar powered drones, and in general mechatronics, autonomous systems and robotics as part of student projects in engineering courses. Also, solar-powered drones and robotics for STEM programs.

4. Of the classes YOU teach, which can best address one of these big ideas through SL?

ME115 Instrumentation and Measurement (incorporating in the final project in this course)

ME159 Mechanical Engineering Laboratory (incorporating in the final project in this course)

5. What are the things you want your students to know or have done or have experienced by the end of this course (don't look at current outcomes yet!)

Learn about the dynamics and mechatronics of solar powered drone systems, and particularly about the applications such as security, and limitations, and how to provide service.

6. What is the catalogue description for this course?

There are final projects for both courses and I would like to encourage the students to do a project that is relevant to service learning rather than any arbitrary project.

7. Now list (or paste) the Learning Outcomes for your course below.

ME115:

Upon completion of this course, students will be able to:

1. Understand applications and limitations of common sensors and actuators used in modern engineering systems with sufficient depth to be able to select an appropriate sensor or actuator for a specified application.
2. Program and use a microcontroller to solve a specified engineering problem.
3. Build an electronic circuit given a circuit diagram / schematic and the required components.
4. Design and implement an integrated electro-mechanical system using the components and

techniques covered in the course.

5. Work with a partner in designing a mechatronics system.

ME159:

1. Operate and collect data from common engineering systems.
2. Perform computer data acquisition and control
3. Design and implement mechanical engineering experiments to evaluate system performance.

8. Generate new learning outcomes for the syllabus based on this exercise if applicable.

Design a system and perform experiment with applications to service learning. The service can be related to providing a service to the community (e.g. community safety/security/monitoring/robotic maintenance, in collaboration with the police department, or providing teaching services for STEM programs). The particular interest of the projects is related to the application of solar powered autonomous vehicles.

9. a. Which one(s) could be met by SL:

Both providing services for safety/security/monitoring, and STEM education can be met by SL.

- b. Which one(s) might be BETTER met by SL than in a traditional manner:

The service component.

10. What community partners might you want to partner with?

These are the potential partners:

- 1) Having your students work with elementary, middle-school or high school students, either through a school or a local youth-serving community benefit organization? Your students could help teach them about the basic engineering principles that go into making a drone work. They can teach basic instrumentation and measurement and mechanical engineering principles, which could inform the K-12 youth about basic scientific principles and concepts. Your students would help improve the STEM skills of the students, help encourage more youth to pursue STEM majors/careers, and act as ambassadors of Fresno State and the Lyles College. At the same time, they would be forced learn the basic principles that underlie the courses you teach.

- 2) There may be a few community benefit organizations, such as those listed below, that might be interested in accessing drone technology.

- Local and State parks and wildlife programs, including:
 - Parks and Recreation (PARCS)
 - Department of Fish and Game
- San Joaquin River and Conservation Trust
- UC Cooperative Extension (perhaps having your students present workshops for local farmers and ranchers)
- San Joaquin Valley Air Pollution Control District
- Fresno Police Department and local Sheriff's departments (Fresno, Madera, Tulare, etc.)
- Police Departments

11. In a brief paragraph, discuss a possible project. Remember, the SERVICE can be direct, indirect, or advocacy:

-Students develop teaching materials for STEM education and offer the materials in schools. The project is related solar powered vehicles (e.g. drones).

-Students investigate how the police department can benefit from solar powered drones, as long endurance aerial vehicles, in providing security, safety and monitoring. Examples of applications can be campus security and traffic monitoring.

12. Discuss how and why your project is Service-learning, and not Volunteerism, Internship, etc. (you might want to look below first):

Students should learn about the dynamics and mechatronics of the drone systems and then offer that for STEM education or providing service to the community for security/safety/monitoring, e.g. in partnership with the police department.

13. Think even more about your project. Does it meet the three criteria for SL? How?:

1) Does it ENHANCE academic learning? How?

Yes, the students learn about mechatronics, robotics, and dynamics particularly related to drone systems.

2) Is it Relevant and meaningful service with community? How?

Yes, providing STEM education, or safety/security/monitoring in partnership with police are services for the community.

3) Is it purposeful civic learning (preparing students to be active in the community)? How?

Yes, students will be active in the community such as schools for STEM education and also providing safety for the community in partnership with the police department.

14. Now go further:

1) Is it high quality Service-Learning? Why? What are reasons someone may take a different judgment?

Providing STEM education is a high quality service.

Community safety and security are of high quality service.

2) Is the link to the curriculum and outcomes strong and clear? Why? What are reasons someone may take a different judgment?

Yes, the students should learn about the engineering systems as part of their project in the courses. There is no difference in this aspect. However in this case we encourage them to learn about drone systems for providing service in addition the technical aspects.

3) Will the students have an experience they wouldn't have if they stayed in the classroom? Why? What are reasons someone may take a different judgment?

An applied and real engineering project is more beneficial in comparison with a corresponding equivalent problem solving on paper in engineering.

4) In pondering the questions, is there a way to further maximize the learning potential of your project? Now, in a brief paragraph describe your project (as if on a grant application) in a manner that demonstrates you have considered all of these questions.

Students should learn about the dynamics and mechatronics of the drone systems and then offer that for STEM education or providing service to the community for security/safety/monitoring, e.g. in partnership with the police department.

-Students develop teaching materials for STEM education and offer the materials in schools. The project is related to teach students about solar powered vehicles (particularly drones).

-Students investigate how the police department can benefit from solar powered drones, as long endurance aerial vehicles, in providing security, safety and monitoring. Examples of applications can be campus security and traffic monitoring.