Executive Summary

The intent of this white paper is to support productive and informed conversations about the role of multidisciplinary efforts at Cal Poly. The paper provides a snapshot summary of various activities and current proposals at Cal Poly, followed by referenced discussions on the question of why promote multidisciplinary education, the problems encountered, and possible organizational models. The paper ends with suggestions for next steps that include: completion of an inventory of existing activities; an analysis of the survey results to find points of convergence and potential opportunities; and creation of a task force, consisting of members who are well-informed of the literature and are interested in program transformation, to develop a strategic vision with goals and conceptual designs.

Although the literature on multidisciplinary education is extensive, it is generally focused on case studies and barriers. Nonetheless, this review reveals important lessons worthy of our attention. These are:

- Barriers to, and mechanisms for, multidisciplinary education are two sides of the same coin.
- The various forms of multidisciplinary structures, as found in the literature, arise predominately from research-focused institutions. Our Cal Poly mission of teaching with our affiliated fiscal practices must be an acknowledged context when evaluating applicability of these structures.
- Multidisciplinary activities are more successful if they also support other institutional priorities, and if there is commitment of leadership.
- Multidisciplinary education presents us with a paradox. One must possess disciplinary expertise before one can contribute to, or learn effectively from, the multidisciplinary space.
- Matrix organizations may be suitable for organizing multidisciplinary research.
- A network of hubs, threads and roles may be best for organizing a multidisciplinary educational approach.

Introduction

Over the past many years, the faculty and students of Cal Poly have been engaged in a variety of activities that fit within the umbrella of multidisciplinary or interdisciplinary education\(^1\).\(^2\). The existing

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\(^1\) For purposes of convenience, the word multidisciplinary is used throughout this white paper even though the ideas and next steps may reflect concepts that reach deeper into the realm of interdisciplinary and trans-disciplinary activities. It is a generalized term to capture intent without specifying the nature of involvement and the disciplines involved. Interdisciplinary (or similar) is used when the reference uses it.

\(^2\) According to Shafritz, Koepppe & Soper (1988), multidisciplinary learning involves several different disciplinary areas though not necessarily in an integrated fashion. Activities draw from knowledge in different disciplines but stays within the disciplinary bounds. In contrast, interdisciplinary approaches bring together two or more disciplines so that the disciplines interact with each other and affect each other's perspectives (Rowntree 1982).
activities and proposals are genuine offers to educate, research or serve, but are limited because they are outside the operating mission and the related organizational, economic and governance structures. Because multidisciplinary activities and programs depend on the will of those involved and the fiscal ability of disciplinary units to fund them, it is impossible to ensure their continuance. Regardless, faculty, staff, our students, alumni and employers are drawn to multidisciplinary teaching, learning and projects. Feedback from a March 2012 strategic framework workshop in the College of Engineering identified “multidisciplinary” as the most important context and goal of our future teaching, scholarship and service. Figure 1, a moodle depiction of one of reports from a small breakout group, exemplifies the prevalence of “multidisciplinary” whether it’s used as an adjective or adverb. Similar expression of interests for interdisciplinary opportunities, team teaching across disciplines, first year common experiences and flexibility in curricula and operations are present at the university-level (Machamer and Schaffner, 2012).

Practitioners and professors alike have an inherent understanding of the importance of multidisciplinary activities or behaviors, especially as it relates to preparing our students to solve the hard problems of the 21st century. We’ve not, however, had the specific conversation and direction to enable a broad-based commitment to a multidisciplinary agenda. We have not informed ourselves of the required elements for launching and sustaining multidisciplinary pursuits; and we have not examined proposals or existing activities within the context of mission, organization, budgets and governance. Our current efforts are many. They are organic, discrete, well-intentioned, often outside the system and unsustainable. Locally, as we think about how Cal Poly will achieve its vision (Figure 2), the value of multidisciplinary structures and activities is apparent. Multidisciplinary could become the backbone of a comprehensive polytechnic education that promotes innovation, systems thinking and global capabilities.

Figure 1 Prevalence of ideas, engineering strategic breakout report, March 2012.

Figure 2 University vision statement, Fall 2012

Trans-disciplinary is integrative and transcends traditional, disciplinary boundaries. Multidisciplinary is additive, interdisciplinary is integrative, and trans-disciplinary is holistic (Choi and Pak, 2006).
This white paper is focused on initiating productive and informed conversations about the role of multidisciplinary education at Cal Poly. The paper provides a summary of various multidisciplinary activities and current proposals followed by referenced discussions on the rationale for multidisciplinary education, the problems encountered and possible models. The paper ends with suggestions for next steps.

**Cal Poly Multidisciplinary Activities**

With the arrival of our new provost in early 2012, Dr. Kathleen Enz Finken, multidisciplinary efforts became a topic of some priority given the number of proposals submitted to the Provost's Office. These included: UNIV task force report along with a proposed Center of Integrative Education; Honors task force report; a proposal for a series of new interdisciplinary courses; SUSTAIN SLO, a work-in-progress report; Cal Poly Innovation complex plus; and a white-paper on interdisciplinary digital humanities support needs. These documents share a focus on student learning and Learn by Doing.

a. UNIV Task Force and Center for Integrative Education

The UNIV task force submitted a report (2012) that explored an alternative to the decentralization of UNIV courses to colleges. The task force recommended development of a Center of Integrative Education to serve as the administrative unit for advancing multidisciplinary education at Cal Poly by coordinating courses, curricula and certificates. The envisioned center includes a director, administrative assistant, student workers and funding to purchase the teaching time of faculty from across the university. The funds to initiate and maintain the center were not identified in the body of the report, but were assumed as university-sourced. The report's appendix, however, identified an additional source: funding from gifts and research grants. In addition to the Center for Integrative Education, the UNIV task force identified four low- to no-cost action items ranging from a hosted interdisciplinary coffee to an electronic repository of projects and connections.

b. Honors Task Force Report

In a similar vein, a task force of faculty and staff met during the winter and spring quarters of 2012 to assess the Honors Program and to make recommendations for strengthening it (2012). Interdisciplinary learning is emphasized as a primary goal of the program. A now defunct undergraduate research program, funded in part from a NSF grant, was a defining feature of Honors. The task force suggests that the program's limitations today are a function of reduced funding. They look to possible gift endowments as a sustainable source of funds. In addition to a number of low- to no-cost suggestions including increasing GPA requirements and requesting priority registration, the Honors Program finds synergy with the Center for Integrative Education and proposes to serve as a pilot project.

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3Integrative education, as asserted by the AAC & U and the Carnegie Foundation (2007), fosters "students' ability to integrate learning - over time, across courses, and between academic, personal, and community life..."
c. Proposed Series of New Interdisciplinary Courses

The proposal to develop and deliver a series of new, interdisciplinary courses builds upon the UNIV course designation, but with a twist. It proposes a rethinking of the General Education program to more effectively utilize UNIV courses. Funding to release department faculty for UNIV teaching would come from the student success fees. Priority would be given to new courses with innovative teaching and learning approaches that reduce the cost of instruction, while enhancing outcomes and student learning.

d. SUSTAIN SLO - A Work-In-Progress Report

The SUSTAIN-SLO project (Schlemer, et. al. 2012) is a project-based, self-directed learning environment where first-year students with faculty from multiple disciplines come together to learn and engage in the community via service projects. The initiative spans winter and spring quarters; it is entering its second year with eight faculty members from English, Biology, Communications, Materials Engineering, Industrial Engineering, Ethnic Studies and Women's and Gender Studies, and Physics. Students enroll in special sections of three General Education courses for 12 units, plus a major specific course. The 2013 winter and spring offerings, along with their general education designation, include: PHYS 104 (GE B3), PHYS 121 (GE B3 & B4), PHYS 131/141 (GE B3 & B4), PHYS 132, BIO 114 (GE B2 & B4), ES 112 (GE D1), ENG 134 (GE A1), ENG 145/149 (GE A3), COMS 102 (GE A2), MUS 229 (GE C3), MATE 270, MATE 240, IME 270 and IME 240. These details are available on the project's website (sustainslo.calpoly.edu).

e. Cal Poly Innovation Complex Plus

The May 2012 proposal for a Cal Poly Innovation Complex describes a physical space to bring faculty, students, and businesses together for student innovation, faculty research, and private research and development. This complex idea is one of many envisioned projects from across campus to provide the building, equipment, laboratory, and fabrication facilities for multiple users. Other proposals include the Agriculture Technology Center; the Engineering Student Project Prototyping and Fabrication Center; a performance space for music, theater, and dance; a production studio for combining creative expression and technology; an academic commons for collaboration and coordination of entities such as the Honors Program, the Writing Program, Academic Skills Center, Multicultural Center, Women's Center, Pride Center, Disability Resource Center and International Educational and Programs. Finally, through the efforts of a diverse group of administrative stakeholders, these many ideas were coalesced into a single concept called the Creative Commons that included (1) a new, sizeable building to serve as the hub of design, manufacture, simulation, production, testing, practicing and performing; and (2) upgraded and re-imagined existing campus facilities. The Creative Commons concept has also been referred to as the Learn-by-Doing Village.
f. Multidisciplinary Digital Humanities Needs

Lastly, faculty affiliated with the Liberal Arts and Engineering Studies program, the Expressive Technologies Studios and ICEX\(^4\) collaborated on a white paper to request support for multidisciplinary work in digital humanities. Their primary need centers around informational technology: specifically, a hosted server with a single IP address and database management system. They also ask for a Cal Poly solution such as a virtual or physical space to sustain cross-department efforts, to learn from each other, to work with each other, to provide IT services and administrative support, to host forums, to focus fund raising efforts toward and to collaborate on research grants.

Reflecting national trends, multidisciplinary activities at Cal Poly are also spurred by innovation and research. The webpage for the Cal Poly Centers and Institutes illustrates this point. Many of the initiatives describe missions that span multiple disciplines, even though most of the entities are hosted by individual colleges. Some of the more active areas include the Center for Coastal Marine Sciences, the Environmental Biotechnology Institute (soon to be called the Applied Biotechnology Institute), C3RP, and Poly GAIT. In addition, Cal Poly has a number of joint-funded research projects that cross disciplines but are not formalized into centers or institutes. This white paper highlights three example efforts: the developing Institute for Advanced Technology and Public Policy, Center for Innovation and Entrepreneurship, and Bridges to Stem Cell Research Grant.

g. Institute for Advanced Technology and Public Policy

This recently approved institute is focused on creating a multi-disciplinary learning environment for constructively engaging in cutting edge policy challenges facing California. The center is being led by a volunteer director and will be housed in the new Math and Science building.

h. Center for Innovation and Entrepreneurship (CIE)

The CIE was started two years ago through the Orfalea College of Business with a mission to foster an interdisciplinary approach to entrepreneurship education across the campus. Their efforts to connect beyond the College of Business are growing as exemplified by the notable activities of students and faculty from the College of Engineering and the College of Liberal Arts. The CIE hosts several high profile programs including the Entrepreneurship Forum Series, the Hothouse Accelerators, the Elevator Pitch Competition, the Entrepreneur-in-Residence program, and the student club named Cal Poly Entrepreneurs. The CIE is supported financially, in part, through its Founders Circle of 26 members who are experienced entrepreneurs and alums. The CIE maintains an effective website to which the reader is encouraged to peruse at [http://cie.calpoly.edu/](http://cie.calpoly.edu/).

\(^4\) ICEX (International Computer Engineering Experience) is a collaborative, multidisciplinary effort between Cal Poly and various international partners. The current student and faculty project focus is the autonomous underwater data acquisition of water distribution systems in Malta. See Lazier (2009) for more information.
i. Bridges to Stem Cell Research Grant (Bridges)

The Bridges grant represents collaboration between faculty in biology, animal sciences and biomedical engineering to offer a master’s program in stem cell research for cohorts of students that complete their coursework at Cal Poly and conduct research off-site at research labs, other universities, or companies. The program is funded through the California Institute for Regenerative Medicine (CIRM), with a total of $2.9 million over a period of six years. The program has graduated two 10-student cohorts to date.

Compelling Context — Why Multidisciplinary

A missing element from most internal presentations on multidisciplinary initiatives is information or discussions about "why." The literature does, however, provide answers about why, especially within the context of research, education and relevancy. In order to minimize misunderstandings and gain common perspectives in our campus conversations, we should make these answers explicit. For these reasons, this paper provides a review of the literature on context.

Klien (2010) captures the many previously written discussions succinctly and summarizes the benefits and opportunities for faculty, administrators, students and partners. She states that “interdisciplinarity⁵: is associated with bold advances in knowledge, solutions to urgent societal problems, and innovations in technology; provides organizational flexibility to respond to new needs, to offer new forms of integrative education, and to establish distinct identities among peer institutions; creates partnerships with government, industry and the community; enhances success in external funding competitions and makes better use of facilities and infrastructure by multiple and collaborative groups; excites new intellectual pursuits in new areas of teaching and research with other colleagues; and is the vehicle for the study of real-world problems by making learning connections and integrating knowledge; and to gain higher order critical thinking, synthesis and collaborative skills.

In terms of research, “interdisciplinary thinking is rapidly becoming an integral feature” (NAS 2004) and is an important factor in the novelty and currency of ideas for securing external funds” (Feller, 2007). World issues, needs and opportunities are becoming increasingly complex; outstripping the capabilities of one discipline to solve (King, 2010). A multidisciplinary focus is also viewed as a teaching and research strategy for capitalizing on scarce resources and for procuring more support in the future (McCoy and Gardener 2012). In terms of education, stakeholders want graduates with the interdisciplinary skills to take on complex jobs in science, policy, business and industry. In an interview for the Detroit Free Press (Bomey, 2012) on why the U.S. is trailing the world in engineering education, John Calabrese, Vice President for General Motors, states that colleges need to create multidisciplinary departments and curricula to graduate engineers with a strong interest in inventing the future.

⁵ Throughout Klien’s work, she utilizes the improper word “interdisplinarity”, presumably as a play on the noun disciplinarity. This word appears elsewhere in the literature as well.
Interdisciplinary study is a platform for achieving integrative learning, going beyond breadth and depth by synthesizing knowledge across courses, between disciplines, and over time (AAC&U, 2007). These enhanced cognitive and intellectual goals were articulated (see Figure 3) by the 28 campuses involved in the PKAL project for interdisciplinary learning (Kezar and Elrod, 2012). Appearance of the word "intentional" in the preamble statement of Figure 3 is no accident, as is discussed further in the next section.

During an academic leadership retreat at Cal Poly in late August 2012, a facilitated discussion focused on "why" multidisciplinary. The following emerged: Multidisciplinary experience is demanded by industry/employers, some accrediting agencies and many external research funding agencies. Multidisciplinary skills and attributes are required for success in life (i.e. life is multidisciplinary) and in the rapidly changing world of the professional. The platform of multidisciplinary activities is consistent with Learn by Doing, our mission as a comprehensive polytechnic university and with our university learning objectives, especially critical thinking, communication, and inclusivity. Finally, it is often in the spaces between disciplines that we make breakthroughs in solving major problems and discover the meaning of complicated situations. As teacher-scholars we have a responsibility to engage in interesting scholarly things as part of our contract with a society, who invested in our intellectual development. These interesting scholarly things are being regularly found in-between, or within merged disciplines.

**Hindrances and Conditions for Success**

Although we are drawn to multidisciplinary promises, we also understand that multidisciplinary activities pose institutional difficulties. Similarly, nearly every article or book on the topic warns of the many challenges; a brief review of these is presented below. It is important, however, to view the literature of case studies from our own Cal Poly context. Much of what has been analyzed and written about is within the context of the research university, where faculty are funded to not only teach, but to also conduct research. This is in contrast to the funding and related workload model of the CSU and Cal Poly. Our faculty's primary mission is teaching, which can foster disciplinary conservatism. Little time is afforded for research and/or innovation and exploration outside the discipline – a process that can

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As the result of intentional interdisciplinary learning experiences, students will be able to:

- Recognize disciplinary strengths, processes, limitations, and perspectives.
- Purposefully connect and integrate knowledge and skills from across disciplines to solve problems.
- Synthesize and transfer knowledge across disciplinary boundaries in the context of novel situations.
- Be agile, flexible, reflective thinkers who are comfortable with complexity and uncertainty and can apply their knowledge to respond appropriately and positively.
- Understand that a host of factors– cultural, political, ethical, historical, and economic– must be considered when addressing the complex problems of this century.
- Understand the universal nature and deep structure of science, as well as the relationship of the disciplines to each other.
- Be prepared for future learning as lifelong learners in their careers and as citizens.
- Apply their capacity as integrative thinkers to solve problems in ethically and socially responsible ways.
- Think critically, communicate effectively, and work collaboratively within diverse cultures and communities.

Figure 3 Interdisciplinary PKAL Learning Outcomes (Kezar and Elrod, 2012)
create mindsets of openness and flexibility.

Stone, et. al (2009) provides a comprehensive review of the literature as it relates to the problems of instituting interdisciplinary initiatives in higher education. Their list of hindrances include the following: the appearance that faculty and administrators are working at cross-purposes; a hierarchy that directs resources (funding, space and authority) to departments; a viewpoint that interdisciplinary work is marginally important; difficulty in achieving a critical mass of participation from faculty, staff and administrators; and cultural expectations regarding research that are biased towards individual achievement. The roles of the discipline and faculty habits of mind are also impediments to multidisciplinary activities.

Strober (2011) dedicates a book to the impact disciplinary culture has on interdisciplinarity, while our own faculty (Vansupa, et. al. 2011) has also revealed incongruences between the intent to collaborate and the habituated relational structures of the disciplines. Finally, Klien (2010) does a great job in pulling all the various barriers and challenges together into one short piece, which is depicted here as Figure 4. Adjacent to the barriers list is a list of conditions or mechanisms for fostering interdisciplinarity. It is easy to posit. Barriers and success form two sides of the same coin: happenstance vs. intentional, inattention vs. attention, invisibility vs. visibility, ambiguity vs. certainty, etc.

Exploring this oppositional proposition further, McCoy and Gardner (2012), who were involved in Maine’s $20 million dollar Sustainability Solutions Initiative, identified five key essential conditions for fostering success in interdisciplinary work. Time is needed to understand other modes of research, to learn the language and jargon of others, and to create the collaborative structures and habits. The right people are needed, and are described as those with a high tolerance for ambiguity.

<table>
<thead>
<tr>
<th>Organizational Structure and Administrative</th>
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<tbody>
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<td>Rigid structure, discipline-based budgeting and administration, turf battles over budget, curricula, and research, status of interdisciplinary is ambiguous, lack of experienced leaders, resistance to innovation and risk, dispersed infrastructure, no clear and authoritative report lines for interdisciplinary units.</td>
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<th>Procedures and Policies</th>
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<td>Inflexible guidelines that inhibit new program and course approvals; rigid and exclusionary degree requirements, lack of guidelines for hiring, tenure, and promotion, and salary; inadequate guidelines for grants management and research collaboration; unfavorable policies for allocation of workload credit in teaching interdisciplinary courses, unfavorable research policies on sharing indirect cost recovery and allocating intellectual property.</td>
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<th>Resources and Infrastructure</th>
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<td>Inadequate funding and ongoing support, number of faculty lines, student assistantships, space and equipment; restricted access to internal incentives and seed funds; competition for funds and faculty between departments; weak or no faculty development program; ignorance of the literature and resources nationally; insufficient time for planning and implementing, to learn the language and culture of another discipline, to develop collaborative relationships.</td>
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<th>Recognition, Reward and Incentives</th>
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<td>Invisibility or marginality of interdisciplinary research, teaching, service, advising and mentoring; reliance on volunteerism and overload; lack of support at department, college, or university levels, negative bias, ineligibility for awards, honors, etc.</td>
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Figure 4  Barriers and Disincentives to Interdisciplinarity (Klien, 2010, pp 72-73).
and who possess effective social networking and interpersonal skills. Department support is important, especially in promotion and tenure criteria. The university needs policies and procedures that support team teaching, to encourage interdisciplinary grant work, and to account for interdisciplinary work as part of the normal workload. There needs to be sufficient financial resources, which, in a closed system, might be available through the retirement of an existing activity or unit. Finally, there needs to be a reallocation of space for offices and labs and the addition of technical resources such as IT to enable connections and communication.

A study (Holley, 2009) of 21 research universities from the U.S. with very high research activity is perhaps one of the more robust articles on interdisciplinary initiatives and transformational change. The author identifies five components important to implementation, including:

- senior administrative support through resource allocation and prioritization;
- collaborative leadership in which multiple groups with decision-making authority are involved;
- flexible vision providing clear direction that can be adapted in response to opportunities;
- faculty/staff development provided to learn needed skills;
- visible action that highlights progress towards short term goals and beyond.

Most importantly, Holley concludes that successful change is facilitated when interdisciplinary initiatives support other institutional priorities, such as research. In other words, interdisciplinarity is not sustainable if it is an add-on or a supplement to the core mission. As stated by Provost Mancuso of the University of Guelph in Ontario Canada (2011):

While the University appreciates the importance and value of an interdisciplinary perspective, we have rarely explored critical questions about the sustainability of these programs, especially in an era of limited resources.

Finally, Kezar and Elrod (2012) suggest that there are many examples of planning, mobilization and implementation. However, when it comes to the final stage of change in which interdisciplinarity is incorporated into the cultural systems and day-to-day norms, few campuses have taken this step. Perhaps the difficulty of instituting interdisciplinarity lies in a paradox. Consider the individual faculty member who must first possess disciplinary expertise before moving into a multidisciplinary space. The same is true for our campus structures. The extraordinary complexity of knowledge today demands disciplinary specialization; departments are ideal settings for this. However, the problems of the 21st century transcend disciplinary boundaries. As noted by Strober (2011):

The difficult task for faculty and administrators is to retain the benefits of disciplinary specialization while at the same time fostering interdisciplinary collaboration.

**Forms and Models**

Although making the academic case for multidisciplinary activities is easy, implementation is difficult because of traditions, institutional barriers and inherent paradoxes. With time and courage, however, a
few will succeed in a big way. Take, for example, Arizona State University. ASU self-identifies itself as the New American University to advertise their alternative approach to the design and operation of a large research university. They have been actively reformulating traditional disciplinary units into schools and colleges focused on the emerging problems of the 21st century by merging the disciplines. At that institution, the College of Engineering includes five schools with names like biological and health systems engineering or sustainable engineering and the built environment. Although a strong institution prior to the presidency of Dr. Michael Crow in 2002, ASU’s impressive redesign is yielding successes in student access, educational quality, local economic development, and social embeddedness. These successes are being attributed to leadership and the will to transcend disciplinary limitations, to devolve intellectual and entrepreneurial responsibility to the level of college and school, and to create a federation of unique and autonomous colleges, schools, academic departments and interdisciplinary research centers (Tornatzky, n.d.)

Klien (2010) presents a table of form and structure — in other words, models — for interdisciplinary activities in higher education. These models range from simple, where the structure is familiar and there is a single set of operational rules, to complex systems of non-hierarchical structure with multiple and conflicting logics. These complex structures may be interconnected in a shifting matrix with feedback loops and unpredictable relationships.

King’s words (2010) are encouraging: "If faculty members really want to get together ..., they will find ways to do so independent of what structures exist." This belief is evidenced by faculty at UC Berkeley, who on their own developed a center for study and work within the multidisciplinary area of catastrophic risk management. King’s belief and evidence form her organizational thesis. Cross-matrix (or simply, matrix) structures, which she calls Organized Research Units, are effective for fostering multidisciplinary research. One imagines that this structure might conceptually look like Figure 6, with faculty, staff, students and resources from various departments or colleges committed or released to the various research problems that are organized into research units, such as centers and institutes. Like departments and colleges, research units have autonomy, budget and/or a mechanism for an exchange of value, leadership and staff. The matrix structure seems particularly applicable to the research institution and its operational practices: faculty workloads that include substantial time for research and external grant funding as an important source of funding to stand-up and sustain the
research unit. Like all fixed systems, practices established to end research units are as important as the practices to initiate projects and units. To keep the benefits of flexibility and responsiveness, the university needs to know when to stand-down research units to make room for new and have the ability to do so.

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<th>Research Unit</th>
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<td>Departments/ Colleges</td>
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**Figure 6 Matrix of Disciplinary Units with Multidisciplinary Research Units**

The literature on multidisciplinary education can be described as post-mortem-like, consisting of multiple analyses of institutional case studies from which insights are drawn. Most of the mechanisms and forms identified as supportive of multidisciplinary education are generally well-known, except in one case. In an op-ed piece for the New York Times (2009), Taylor makes six controversial suggestions to restructure higher education to make it more agile, adaptive and imaginative. Of interest to this white paper is his reference to a curriculum and disciplinary structure modeled as a web or network. Although not nearly as controversial, Ivanitskaya, et al. (2002) similarly hints to the concept of threads (in threading disciplinary hubs together, that is) where humanities coursework is the thread to stitch or connect disciplinary hubs together. CSU-Chico (McPartland, 2012) pushes the concept of threads further in its redesigned general education (GE) program. Students choose an interdisciplinary "pathway" of GE requirements that are a thematically linked series of courses, which also lead to a minor. The value of a GE pathway (i.e. thread), therefore, becomes more strongly evident to the undergraduate student and to external stakeholders, such as employers. The pathway makes GE more coherent to the student. Externally, the B.S. degree retains its disciplinary value, while the minor explicitly signals a capacity for breadth.

The network of hubs and threads as an organizational model for the new university of the 21st century is extensively explored by DeMillo (2011). Though his thesis is not about multidisciplinary education, it could be. And, his thesis is really not that new, but it is rarely applied. Instead of a rigid, sequential, highly constrained and standardized or core curricula, De Millo advocates for threaded curricula. Threads replace core curriculum and represent broad skills. Emanating from disciplinary hubs, threads either stitch hubs together or they can be intertwined to make a degree. He also recognizes roles.

During Charles Elliot’s tenure as president of Harvard (1869 - 1894), the classical standardized curriculum was overthrown, led by students who devalued classrooms in favor of networks, associations and experiences more relevant to their career goals. And, as De Millo states (p. 156), "In the 21st century, the successful universities will be the ones that have learned how to capture the passion of those students.” And it follows how lucky we are at Cal Poly because of our student body. So much of
the Cal Poly reputation and value is about how our students’ passions are directed towards doing within clubs, leadership organizations, design competitions, performances, community service activities and entrepreneurial endeavors. They take on roles (e.g. project manager, fund raiser, team builder, leader, follower, designer, inventor, doer, performer, researcher, practitioner, etc.) through these co- and extra-curricular activities that effectively enhance their curricula into deeper sets of learning experiences.

Taken together, hubs, threads, and roles naturally encompass multidisciplinary learning and activities. The disciplines are preserved. The flexible thread concept stitches together the skills and attributes that arise from multi-, inter-, or trans-disciplinary activities. The encapsulating roles, if integrated into degree requirements, strengthen student learning and harness student interest through application. As stated by Klien (2010, p. 1):

> Images of knowledge as foundation or a linear structure have been replaced by a network and a web. Images of the curriculum follow suite, supplanting fragmentation and segmentation with integrating, connecting, linking and clustering.

The idea for a platform of many disciplines knitted together in multiple ways by threads of focus or learning goals is supported by the theories of robust design and anti-fragility. Both concepts rely on a portfolio of strategies of differing levels and approaches; in this case, strategies from the incremental to the transformative, from top-down to bottom-up, or from well-defined change by objectives to a general loosening of the barriers and power centers. A flexible network of many strategies, activities and forms stands in contrast to the adoption of a single form or model, which is much more likely to fail because it does not have the capacity to adjust.

**Next Steps**

Incorporating and sustaining multidisciplinary education is no small task. Interdisciplinary change is complex because it is counter to the traditional (and valuable) ways of thinking, behaving, organizing, planning, teaching, deciding and budgeting. Interdisciplinarity is distributed, diverse and often concealed. So, what should we do?

We need to decide if multidisciplinary education is important enough to initiate and then invest in a structured process of discussing, planning, piloting, strengthening and implementing. Is this a platform that benefits our future by helping Cal Poly define and re-conceptualize its value for the 21st century and re-create its operating practices and principles accordingly?
An inventory of the existing interdisciplinary programs would be helpful. It should, however, be sophisticated enough to not only capture the overtly obvious, such as centers and programs, but to also capture interfaces and the less visible ventures, such as cross-listed courses, shared facilities, faculty interest and knowledge production (Klien, 2010). The inventory could also include a survey of concerns, interests, barriers and support mechanisms. A multi-variant analysis of results should follow along with making the collected documents and results public. Most likely, this work will reveal points of convergence and potential opportunities.

A task force led by a key administrator could be created. It would be important that the members of the task force become familiar with the variables of organizational change, the local nature of our organization, the literature on multidisciplinary education, and the state of change across the nation. The task force could be charged with the development of a strategic vision with goals, followed by conceptual design solution(s) for consideration by the campus community.

I end this white paper with a word of caution and the proverbial wisdom of throwing out the baby with the bath water. Cal Poly does a fantastic job of preparing our students to serve and contribute as professionals and leaders. However, the world around us has changed and will continue to change at an ever accelerating pace. Our funding situation has also changed dramatically, with state funding eroded from nearly 100% of the cost of educating a Cal Poly student to about 40% today. We must marshal our intellectual capacities to create different operational approaches and funding solutions to sustain our excellence. And, we must acknowledge that many others are successfully deploying problem-based learning techniques and are advancing these techniques through pedagogical scholarship. The educational gap between Cal Poly and others is closing. Research-focused universities are successfully turning into student-centered universities while simultaneously maintaining their core research function and growing their entrepreneurial accomplishments. As we think about how Cal Poly will achieve its vision, maintain its reputation and continue to add value, all in the face of challenges, the potential of multidisciplinary structures and activities could be important to that future. Our trick will be to sustain and to not discard the essential baby (i.e. our Day-One-Ready graduates) while refreshing the water (i.e. curricula patterns and organizational structures).

References


Tornatzky, L. n.d. Arizona State History. Case study chapter in soon to be released publication on Innovation U.


