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Chair of the Assembly of the Academic Senate
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University of California
1111 Franklin Street, 12th Floor
Oakland, California 94607-5200

October 26, 2017

MICHAEL T. BROWN
PROVOST AND EXECUTIVE VICE PRESIDENT
UNIVERSITY OF CALIFORNIA

Re: Approval of Master of Molecular Science and Software Engineering (MSSE) degree UC Berkeley

Dear Michael:

In accordance with the *Universitywide Review Processes For Academic Programs, Units, and Research Units* (the "Compendium"), and on the recommendation of CCGA, the Academic Council has approved UC Berkeley's proposal to establish a self-supporting graduate program leading to a Master of Molecular Science and Software Engineering (MSSE) degree.

Because this is a new degree title, and the Assembly of the Academic Senate is not meeting within 30 days of CCGA's approval, Council must approve the program per Senate Bylaw 125.B.7.

I am enclosing CCGA's report on its review of the new program, and respectfully request that your office complete the process of obtaining the President's approval.

Sincerely,

A handwritten signature in black ink, appearing to read "Shane N. White".

Shane N. White, Chair
Academic Council

Encl

Cc: Academic Council
Senate Director Baxter
Senate Executive Directors



COORDINATING COMMITTEE ON GRADUATE AFFAIRS (CCGA)

Karen Duderstadt, Chair
karen.duderstadt@ucsf.edu

ACADEMIC SENATE

University of California
1111 Franklin Street, 12th Floor
Oakland, California 94607-5200

October 16, 2017

ACADEMIC COUNCIL CHAIR SHANE WHITE

Dear Shane,

Following the October 4th meeting, the Coordinating Committee on Graduate Affairs (CCGA) voted to approve the University of California Berkeley (UCB) Department of Chemistry/ College of Chemistry proposal to establish a self-supporting online graduate degree program leading to a Master of Molecular Science and Software Engineering (MSSE). The program will be coordinated with the UCB College of Engineering (CoE), the Fung Institute, and the Computational Data Science and Engineering (CDSE) group.

The proposed UCB MSSE program curriculum will train post-baccalaureate students in computational science, software engineering practices, and in addition work on leadership skills with the goal to manage large software enterprises. The program targets recent graduates with work experience in the fields of science, engineering, math, and technology programs and features a two-year part-time online program designed for those working in the industry. The MSSE program is scheduled to begin in fall 2018, pending final approval. Students are required to complete a two-quarter group capstone project.

The UCB Department of Chemistry/College of Chemistry was one of eight universities awarded S212 funding from the National Science Foundation (NSF) to establish a hub of excellence in software infrastructure and technologies which will support development of the program, as well as a loan from the UCB Operation Excellence (OE) Program Office to support costs of establishing the online curriculum.

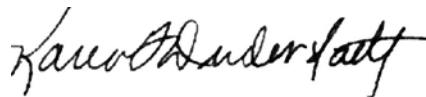
The reviewers for the proposal included two internal (UC) reviewers and two external reviewers. Margot Merritsen from Stanford University and Francois Gygi from UC Davis participated in the proposal review. One internal UC faculty member and one external non-UC reviewer requested their reviews remain anonymous to the proposer. The reviews were generally positive about the quality of the program and the proposed program structure. They did raise concerns about some of the program structure including need for clarification of program prerequisites, narrow application of the proposed program, and the faculty workload for the supervision of the capstone projects for the proposed student enrollment. In response, these concerns were sufficiently addressed by the proposer.

UCPB also reviewed the proposal upon the request of CCGA. UCPB generally supported the program, but raised some concerns about the amount of faculty workload in administering the proposed program. UCPB did comment that the proposed program would be of significant long-term benefit to UC and UCB, and would train individuals in an area of need as defined by the NSF funding.

A question did arise during the CCGA and UCPB reviews in regard to the OE Program \$1 million loan to support establishment of the UCB online Master's program. The proposal did not include a discussion of repayment of the loan. The program proposers responded to CCGA's request for further information and the current UCB plan is the loan repayment will begin in May 2020 with four annual payments ending in May 2023.

CCGA has completed the review and approval of the UCB MSSE program proposal and we submit it to you for final approval. I have enclosed the lead reviewer's final report for your review which provides further details about the reviewers comments and the responses from the proposer. Please do not hesitate to contact me if you have further questions about our review process.

Respectfully submitted,



Karen Duderstadt
Chair, CCGA

Enclosures (1)

cc: Robert May, Academic Council Vice Chair
CCGA Members
Hilary Baxter, Academic Senate Executive Director
Kimberly Peterson, Academic Planning Analysis Manager
Chris Procello, Academic Planning and Research Analyst
Lisa Alvarez-Cohen, UC Berkeley Divisional Chair
Andrea Green Rush, UC Berkeley Academic Senate Executive Director
Sumei Quiggle, UC Berkeley Academic Senate Associate Director

Report for the UC Berkeley (UCB) Proposal for a Self-Supporting Online Graduate Program leading to a Molecular Science and Software Engineering (MSSE) degree

October 16, 2017

This proposal is to establish a new, self-supporting graduate online program leading to a Molecular Science and Software Engineering (MSSE) at University of California, Berkeley. The MSSE program trains post-baccalaureate students in computational science, the best engineering practices for software, and develop the necessary leadership and management skills to lead large software enterprises. The program will be administered by the Department of Chemistry. The proposed MSSE program also received a grant from the National Science Foundation (NSF) and a loan from the Operational Excellence Program Office for the start up phase of the program.

The proposal was reviewed by four qualified reviewers in the field, two from within the UC system and two from outside. One internal (UC) reviewer (Reviewer 1) and one external (non-UC) reviewer (Reviewer 2) opted to remain anonymous. The other two reviewers are Margot Merritsen from Stanford University (Reviewer 3) and Francois Gygi from UC Davis (Reviewer 4). In addition, UC Planning and Budget (UCPB) reviewed the proposal and provided comments to CCGA. In general, all reviewers and UCPB were supportive of the proposed program. However, the reviewers raised some concerns and suggestions, as well as providing some constructive comments that the proposers systematically addressed in their response and revised proposal. The reviews were provided to the proposers. The proposers addressed the key concerns raised by the reviewers' and UCPB's comments. I recommend that the proposed UCB Master's in Molecular Science and Software Engineering be approved.

The program will bring national and international visibility to the Berkeley Master's program through direct affiliation with an NSF sponsored software institute, MolSSI, that will allow MSSE students to directly engage with worldwide partners in academia, government labs, and industry in their capstone projects.

I. Descriptions of the Program

Structure of the MSSE program

The program will be administered in the Department of Chemistry within the College of Chemistry (CoC) with content coordinated with the College of Engineering (CoE), the Fung Institute, and the Computational Data Science and Engineering (CDSE) graduate group, at UC Berkeley.

It is a 29-unit Professional Master's degree that targets the pool of academically exceptional prospective students who are relatively recent college graduates who majored in Science, Engineering, Math or Technology, some of whom have work experience in these fields, with an intent to return for a graduate degree. The part-time two-year program will offer tremendous value by providing deep technical expertise in

computational science and software engineering while also enhancing their leadership, management, and entrepreneurial skills with an ethical focus.

The MSSE program will coordinate with the National Science Foundation (NSF) sponsored Molecular Sciences Software Institute, MolSSI (<http://bioeng.berkeley.edu/news/head-gordon-leads-berkeley-partnership-to-improve-scientific-software>). The NSF has created a special class of awards, the S2I2 awards, that are focused on the establishment of long-term hubs of excellence in software infrastructure and technologies, and which will serve a research community of substantial size and disciplinary breadth. The chemical and materials sciences were recently recognized by this mechanism to create the \$19.4M MolSSI center involving 8 universities that includes UC Berkeley.

Enrollment projections.

The program hopes to admit a first cohort of 50 students for the Professional Master's MSSE program in the Fall of 2018, and new students will be admitted each Fall semester thereafter. It estimates a matriculation rate of ~15 additional new students/year over 2019-2022, and enrollment is projected to stabilize at ~100 new students per year by 2023. This enrollment growth will not conflict with the campus enrollment plan since nearly all of the proposed coursework will be online. The estimated proportion of in-state, out-of-state, and international enrollment will be roughly 1/3 each.

Return to Aid for Students

The demand for skilled software engineers in the computational sciences (broadly define) with management skills is high. Financial aid will be available to students in the form of federally guaranteed student loans from the start; the program also plan to dedicate a proportion of our earnings to need-based financial aid (10% of projected net revenue) from Year 1, before it begins to generate revenue. The program is expected to generate enough surpluses to share with MolSSI and cover the implementation costs. Each year's subsequent class is anticipated to increase by 15 until a steady state of 100 new students in each class year is reached. The subsequent years have comparably fewer annual costs than start-up, and if the program achieves the projected enrollment, it will generate surpluses that will benefit the future academic and research missions of the MSSE Program. If faculty teach the MSSE courses as overload they are supplemented with summer salary from the MSSE program. If instead they teach MSSE courses as part of their regular teaching loads, then the MSSE program will provide lecturer support for the department to deploy as they are needed.

Administering the MSSE program

The Chemistry department in the College of Chemistry at UC Berkeley will administer admissions, financial and degree compliance aspects of the MSSE Professional Master's degree. The department has budgeted for appropriate staff and space to conduct admissions, academic advising, distribute financial aid, perform GSI assignments and perform degree requirement verification with the Graduate Division.

Relationship of proposed program to existing programs in the UC system

UC San Diego launched a Graduate program in Computational Science, Mathematics and Engineering, including a stand-alone M.S. degree in Computational Science. It is primarily an academic, research-oriented master's degree. MSSE's emphasis is on scientific software and management skills. UC Davis has established a small sub-group in Computational Science and Engineering that is part of the larger Applied Sciences and Engineering department. It provides a traditional Ph.D. with no Master's options.

II. Strengths and need of the proposed program highlighted by reviewers

- a.** There was unanimous recognition by the reviewers that the expertise of faculty as a strength. The faculty are very well-qualified, with the appropriate areas of expertise, and of an adequate size to administer the program.
- b.** The rationales for setting up the program are well thought out and valid. There is a great market need for graduates with a combined background in algorithms, software, and physical science or engineering. Overall, the reviewer believes that there is interest in the national community for such a program at the Master degree level for persons to acquire important skills.
- c.** The reviewers praised the quality and academic rigor of the proposed MICS program. The curriculum is rigorous. Some of the courses look very worthwhile.
- d.** The reviewers universally recognized the high quality of the participating faculty and expressed their involvement is a strength of the program.
- e.** The program took serious the effort to outreach women and URMs to promote diversity.
- f.** The curriculum includes the teaching of data ethics. The ethics course is a requirement for the degree.

III. Challenges and weakness pointed out by the reviewers

Target Audience

Reviewers raised questions about the curriculum design and the target student populations. Some are not sure if the program's curriculum is broad enough to attract enough students.

Reviewer 3:

“From market analysis it seems clear that the most attractive aspects of such a MS program would be software engineering skills (see separately below), data analytics (which I assume include machine learning) and to some extent leadership and related skills including teamwork. Your initial offering, however, is not a general program in these areas. Rather it is (still) focused on a relatively narrow application.”

On the other hand, Reviewer 1's concern is that "if this program were to replace chemistry for materials with Data Science at some point even as an option, as mentioned in the proposal, it would be a back door to the establishment of a Data Science degree program that would generate a great deal of controversy system-wide."

Reviewer 2 commented that the curriculum's structure lacks organization; It overspecializes some areas (e.g., molecular science) but overlooks others. This goes against the goal of the program to produce broadly trained computational scientist. Reviewer 2 also considered some of the requirements (e.g., the requirement for having taken linear algebra) for applicants to be arbitrary. For example, the proposed program offers a course in advanced methods of electronic structure for chemists. Reviewer 2 wrote: "That is a poor choice for two reasons: (1) it is far too specialized and (2) it would require a graduate course in quantum mechanics as a prerequisite."

The language used in some parts of the proposal was too vague, Reviewer 2 also pointed out: "Furthermore one does not state prerequisites in language such as 'some exposure to basic programming.'"

Capstone project

Reviewers warned about the workload for faculty to supervise capstone projects for MSSE students.

Reviewer 4: "One concern regards the future workload associated with capstone projects if the program successfully grows to include a hundred students. This may be temporarily mitigated by hiring a sufficient number of lecturers, although eventually the issue should be addressed by contributing departments by allocating additional FTEs to computational science when hiring new Faculty."

Reviewer 3 "Capstones are wonderful things, but just like software engineering classes, if you want capstones to truly advance skills of students, the capstones need to be both extremely well designed and really well mentored. With 11 or 14 faculty advising capstones, 100 students per year means 7 capstones per faculty. That is a lot."

Admissions

Given the diversity of the applicants' background, screening based on GPA, GRE and other scores may not be adequate, and a detailed assessment of each applicant may be necessary.

Viability

Can an online program be competitive? While other reviewers believe that the program would attract students eager to developing technical expertise in computational science and software engineering, Reviewer 3 suggests that there are many excellent on-campus programs that arguably offer more rigorous training.

Reviewer 3 wrote: "Excellent students (the kind you'd like to attract) will get MS offers from on-campus programs also and likely PhD programs. So, the question I'd have asked

is not so much whether they see value in the program, but value over and beyond alternatives. For example, an outstanding student from Stanford could complete a co-term in ICME for the price of one additional year (less than the online program) and arguably get as much out of it. Students from state schools can probably go to a MS degree program in state that is as expensive but offers face-to-face experiences and networking possibilities.”

Loan Repayment

UCPB pointed out in its review that no discussion of repaying the \$1M campus loan for course development (from UC Berkeley’s Operational Excellence Program Office) was included.

III. Proposer’s response to Reviewers’ Comments

Curriculum

Proposers said they have been making changes and adjustments to optimize the curriculum with the comments they received, such as expansion into other areas such as machine learning, data analytics, finite element modeling, etc. sooner rather than later.

In particular, one of the faculty Professor Phil Colella will organize his introductory course into the “13 motifs” of scientific software engineering, and the program is actively adapting the scientific domain courses around those motifs. Additional courses will introduce to address the gap. Some faculty are already considering how to reformulate the physical sciences courses to emphasize algorithms, numerical analysis, software engineering, data analytics, etc. illustrated with domain specific examples.

As for the prerequisites, they clarify that they are trying to provide some guidelines for applicants so that students do not expect the program’s faculty to teach remedial undergraduate material; the audience is physical scientists and engineers and the degree is post-baccalaureate after all. However, the proposers responded that they could be flexible with the required prerequisites; they could waive a prerequisite requirement through “permission of instructor.”

Capstone

On Capstone, the proposer is optimistic that there will be more FTEs in the future to address the need.

“We appreciate the reviewers point about the need for FTEs in interdisciplinary areas and the problems of finding the right home. At UC Berkeley we created two successful interdisciplinary programs in which we were granted 10 FTEs each: one in Computational Biology and the other in Nanotechnology. If the program is successful, we are hopeful that this is a future possibility.

The proposers added that many capstones would be defined by faculty but just as many would be formulated through industry and government labs and connections through Fung and MolSSI. Faculty are compensated for their oversight of capstones.

Market Competitiveness and Viability

In response to Reviewer 3, the proposers responded that they had conducted three types of market analysis to gauge demand for the MSSE degree. These market analyses indicated that MolSSI and the more narrow focus on the physical sciences tapped into a large pool of undergraduates and early career professionals who were concerned about declining opportunities in standard physical science industries (like chemistry), and who saw a boom in software engineering, and were looking to translate into new fields quickly through an MS degree (the general conclusion from the OEPO study).

Second, the proposers are fully aware that course content in the physical sciences domains must emphasize software – and not the science – and they responded by saying that they had already carefully considered how to better integrate the domain specific courses to build upon the CS and Stat courses (the rough BRCOE conclusion). They are aware of the need to actively expand course offerings in the near future outside scientific computing into a broader set of skills.

Student Quality

The proposers believe the online program targets an important demographic that remains untapped - working professionals who cannot leave their jobs or family for an in-person degree from a quality institution for an extended time.

On the question of student quality, the experience of BioE's MEng program is of important referential value. The hard data from the MEng vs. BioE PhD program just does not support that conclusion; the proposers see no qualitative differences in grades, institutions, and GRE scores of MS v. PhD students.

Timetable of Loan Repayment

In response to the question raised by UCPB, the proposer indicated that the loan from OEPO must be repaid in four annual payments beginning in May 2020 and ending in May 2023.

IV. Conclusion

In summary, the proposed program addresses a need for a program that trains MS students in computational science, the best engineering practices for software, and develop the necessary leadership and management skills to lead large software enterprises. The proposed MSSE program also received a grant from the National Science Foundation (NSF) and a loan from the Operational Excellence Program Office for the start up phase of the program. The program will bring national and international visibility to the Berkeley Master's program through direct affiliation with an NSF sponsored software institute, MolSSI, that will allow MSSE students to directly engage with worldwide partners in academia, government labs, and industry in their capstone projects. Reviewers and UCPB concerns have been adequately addressed in the responses. I recommend its approval.

Kwai Ng