



Self-Study – Fall 2021
Information and Computer Sciences Department
University of Hawaii at Mānoa

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Introduction

The Department of Information and Computer Sciences (ICS) at the University of Hawaii at Mānoa focuses on the study of the description and representation of information, and the theory, design, analysis, implementation, and application of algorithmic processes that transform information. The computer science degree draws on a solid foundation in mathematics, computer science theory, scientific principles, and experience gained through practice as it applies to software engineering and research. Students are challenged in a problem-based learning environment that allows them to develop their knowledge in such areas as algorithms, artificial intelligence, database systems, data science and machine learning, high performance computing, human-computer interaction, information assurance, networking, security science, software engineering, augmented and virtual reality, immersive and large-screen interactive environments, and visualization.



The primary location of the ICS Department is the Pacific Ocean Science and Technology (POST) building on the Mānoa campus.

The ICS Department is primarily located on the third floor of the Pacific Ocean Science and Technology (POST) Building on the Mānoa campus. The POST facility contains the main office, most computer science faculty offices, two large teaching/learning labs, a student commons, and research labs. The Laboratory for Advanced Visualization and Applications (LAVA) is located in Keller Hall.

History

The formative roots of the ICS Department extend back to the late 1960's. At that time, the University of Hawaii began a project to provide radio-linked satellite computers to the existing University time-shared computing system. The purpose of this project, then known as the ALOHA system, was to make the full information processing capabilities of the central computing facility on the Mānoa campus available to all operating units of UH on Oahu and the neighbor Islands. Norman Abramson, the principal designer of the ALOHAnet, whose principles formed the design philosophy of the Ethernet, became the first chair of a new interdisciplinary program that awarded a Master of Science (M.S.) degree in Information and Computer Sciences.

During the early 1970's, the Information Sciences program became the Department of Information and Computer Sciences. In the mid 1970's, Professor and Chair Wesley Peterson – awarded the Japan Prize in 1999 for his work on error correcting codes, the Claude E. Shannon Award in 1981, and the IEEE Centennial Medal in 1984 – initiated an interdisciplinary program leading to a B.S. degree in Computer Science. This program is designed to give students an understanding of computers, their operation, programming, and applications, and to provide the knowledge and skill needed for a career in the computer field.

In 1986, the ICS Department joined with three other programs, the Department (now School) of Communication in the College of Social Sciences, the Department of Decision Sciences (now Information





Technology Management) in the College of Business, and the School of Library and Information Studies (now the Library and Information Science program) to provide an interdisciplinary Ph.D. degree in Communication and Information Sciences (CIS). In 1998, the B.A. in Information and Computer Science was established to provide an alternative undergraduate pathway for students interested in the computing field. In that same year, the Ph.D. in Computer Science was established in order to provide a training ground for future researchers and to support expanded research activities within the ICS Department. In 2016-2017, a focus in Security Science was added to the B.A. and B.S. degree programs. In 2018-2019 academic year, the ICS Department established a Data Science track within the B.S. program. In 2019, the ICS Department was a pioneer in establishing a Bachelor's and Master's (BAM, 5-year pathway) pathway for our B.S. program. In 2021, two interdisciplinary certificate programs were established: 1) Data Science in conjunction with the Hawaii Data Science Institute, and 2) Creative Computational Media in conjunction with Engineering, Theatre and Dance, and the Academy for Creative Media.

More detailed information about the ICS Department can be located at:

<http://www.ics.hawaii.edu/>

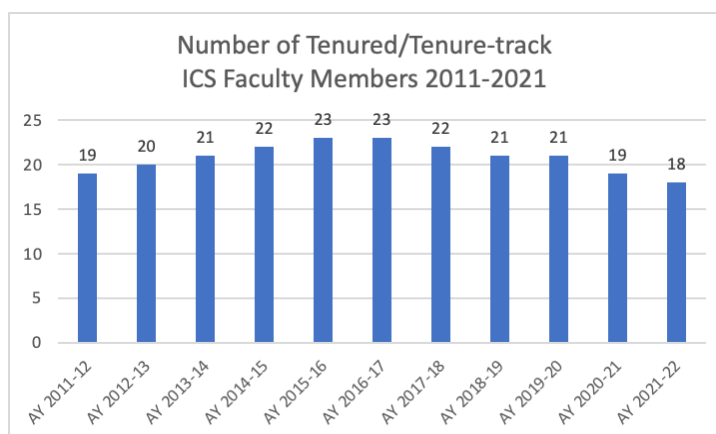
Library and Information Science

Established in 1965, the LIS Program is an American Library Association (ALA)-Accredited, two-year professional Master's degree program, and is the largest Master's offering in UHM's College of Arts and Sciences. LIS merged with the Information and Computer Sciences (ICS) Department in 1997 to build on mutual strengths. In 2022, the LIS program will separate from ICS and join the School of Communication and Information. LIS is not included in this self-study.

Faculty and Staff

The ICS Department, not counting LIS faculty who will move when LIS is reorganized, has 18 full-time tenured or tenure-track faculty members. This includes one faculty member with a split appointment between ICS and the Hawaii Institute of Marine Biology in the School of Ocean and Earth Sciences. The department has also appointed three Affiliate Graduate Faculty from other departments. Affiliate graduate faculty members can serve as mentors and thesis/dissertation committee members. Each year, ICS makes use of temporary faculty and instructors to help meet their teaching requirements.

In response to several vacancies in prior years, the ICS department hired five new faculty members from 2012-2017, and another two in 2018-2019. However, from 2016-2021, the ICS department lost 8 faculty members, primarily through retirement. This returned the department to a faculty level below that in 2011. At the same time, enrollment in ICS undergraduate programs has increased by 61% (see below). At this time, the Computer Science department is top heavy, with 2 Assistant Professors, 8 Associate Professors, and 8 Full Professors. Faculty CVs are presented in Appendix A.





Facts and Figures

Undergraduate Program

Overview: The ICS department offers a B.S. degree in computer science and a B.A. degree in Information and Computer Sciences. Students pursuing the B.S. degree can choose among the General track, the Security Science track, or the Data Science track. Students pursuing the B.A. degree can choose between the General track or the Security Science track.

All of the ICS undergraduate pathways share a common core as follows:

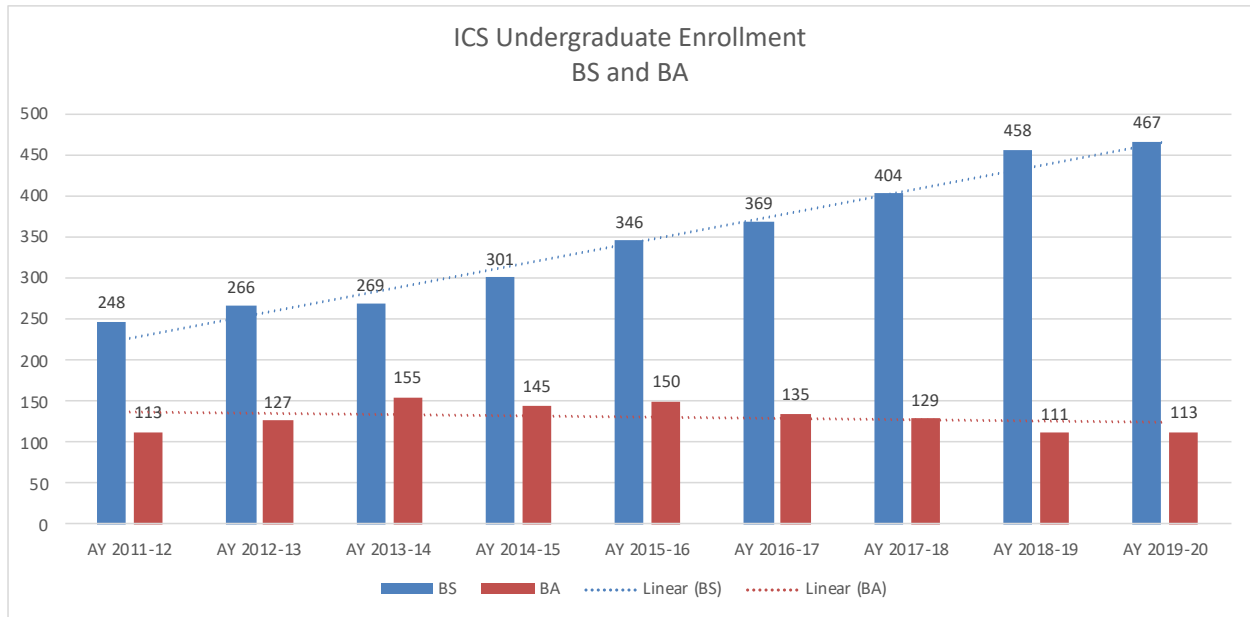
- ICS 111: Intro to Computer Science I (Programming concepts and first language, currently JAVA)
- ICS 141: Discrete Math for Computer Science I (or equivalent)
- ICS 211: Intro to Computer Science II (Data Structures and first analysis of algorithms)
- ICS 212: Program Structure (Introduces C and C++)
- ICS 241: Discrete Math for Computer Science II (or equivalent)
- ICS 311: Algorithms
- ICS 314: Software Engineering I
- ICS 321: Database Systems

The B.A. degree allows students to take more upper division courses in the student's area of concentration outside of computer science. The B.S. General track allows students to select from a variety of upper-division computer science courses and requires the completion of a senior-year capstone project focusing on team software development. The B.S. Security Science track adds a security core and requires several upper-division courses in the security area. The B.S. Data Science track adds greater emphasis on mathematics, data analytics, machine learning and data visualization. The course pathways for each flavor of the bachelor's degrees are presented in Appendix B.

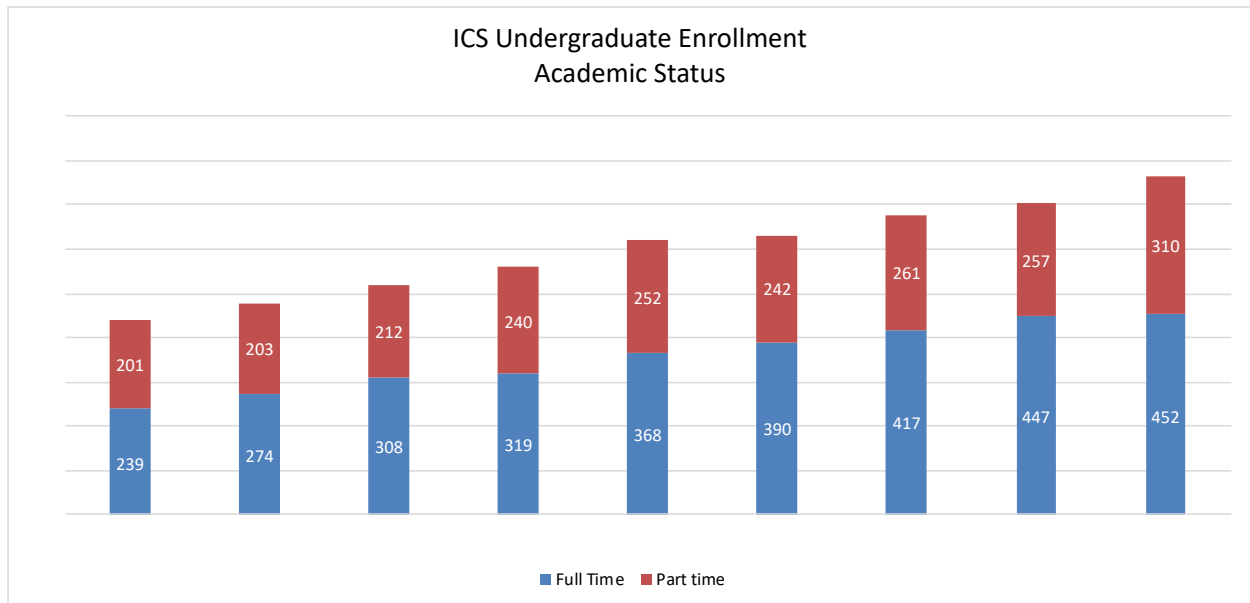
A general overview of most of the courses in the computer science curriculum can be found at: <http://courses.ics.hawaii.edu/>



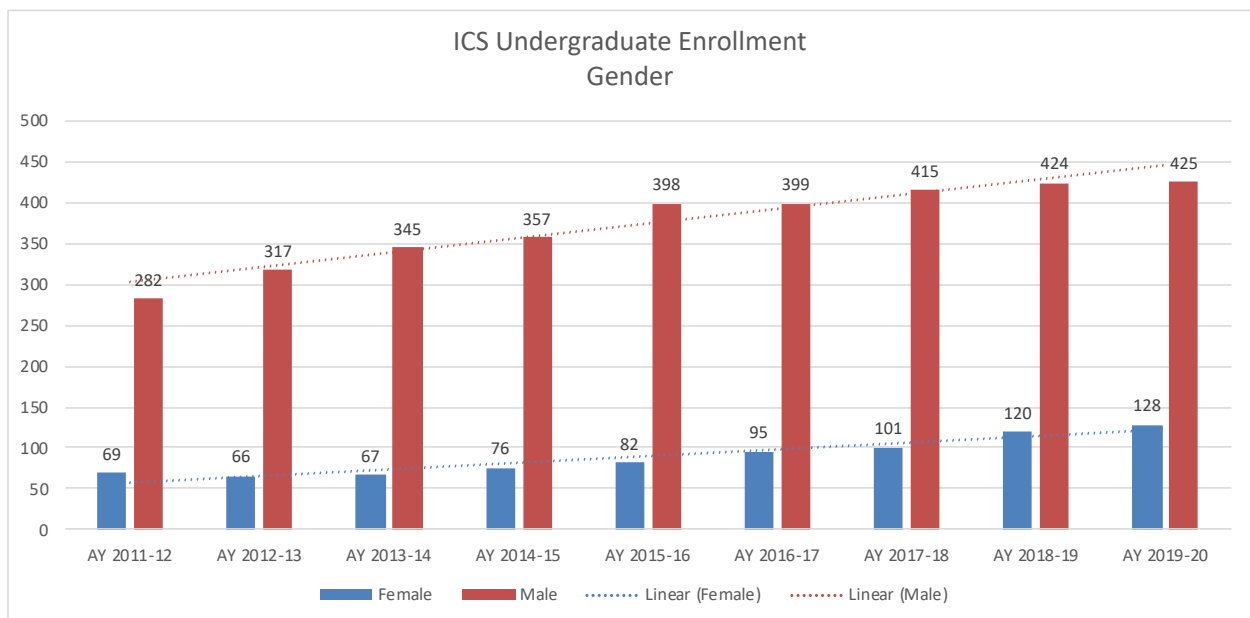
Enrollment: In AY 2019-2020, 580 students were enrolled in ICS undergraduate programs. Eighty-one percent of undergraduates were enrolled in the BS program, and the remaining students were enrolled in the BA program. There are 30 students enrolled in the B.S. Security track, 33 students enrolled in the B.S. Data Science track, and 13 students enrolled in the B.A. Security Science track. Enrollment in the BS program has increased steadily over the last 9 years. Growth in the BA program was level during much of this period, and has been falling since the curriculum changes in 2015 made it less distinguishable from the B.S. degree.



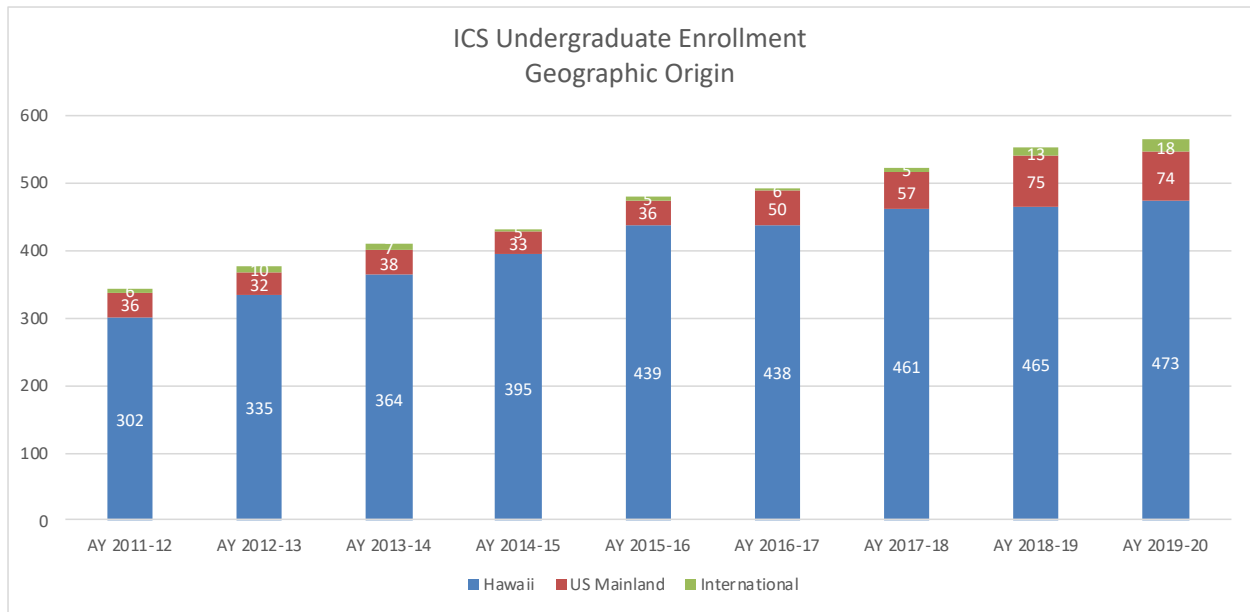
In AY 2019-2020, 59% of current ICS undergraduates were full-time students. This percentage has remained steady over several years.



The gender distribution for undergraduates in AY 2019-2020 was 77% male and 23% female. Representation of women in ICS has increased recently from a low of 16% in 2014, and is now within the standard range for STEM programs nationwide.

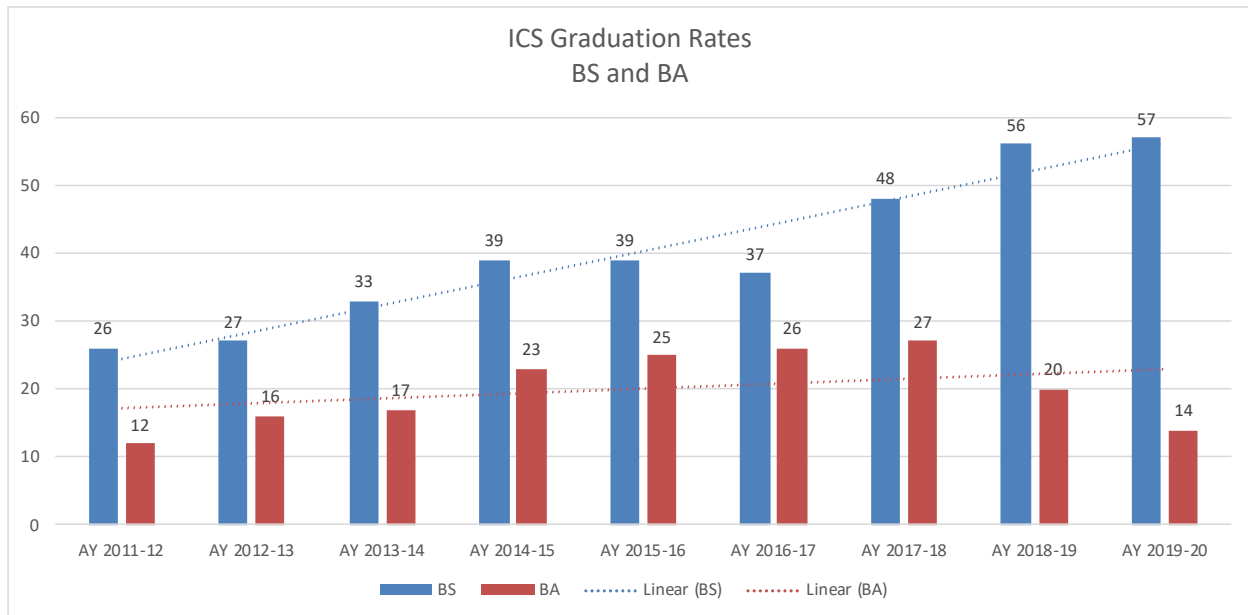


The ICS undergraduate program serves primarily students from the state of Hawaii (84% in AY 2019-2020). Recently, the percentage of students from the U.S. mainland has increased to 13% from lows of 7%-8% in the years 2012-2016. The percentage of international students has been consistently small (3% in AY 2019-2020).

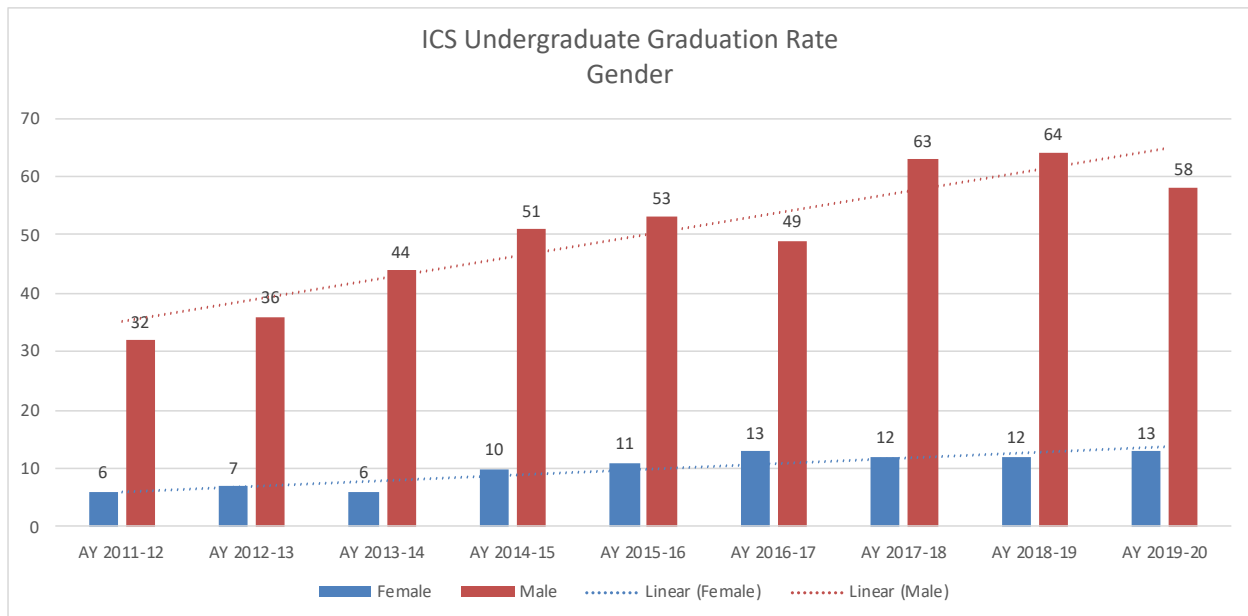




Graduation: In AY 2019-2020, the ICS Department awarded 57 B.S. degrees (a record number) and 14 B.A. degrees. The number of B.S. degrees awarded has doubled over the last nine years, but the number of B.A. degrees has dropped by 50% over the last two years and is now at the same level as nine years ago.

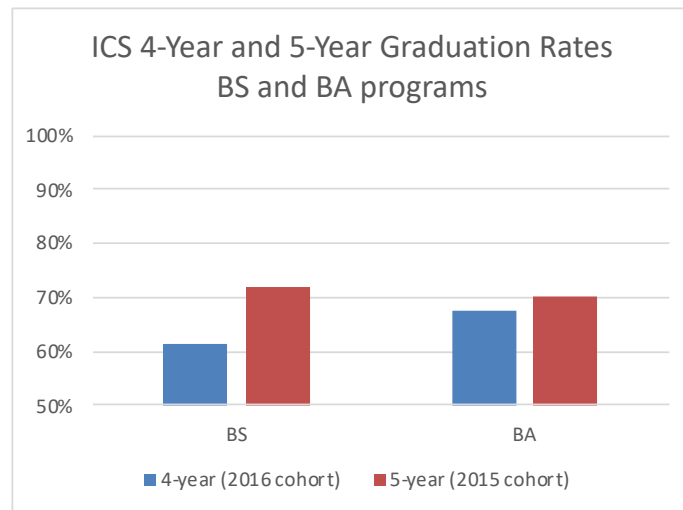


The undergraduate graduation rate for females was 18% in AY 2019-2020, which is consistent with the percentage of females enrolled in the undergraduate cohorts 4-5 years prior.

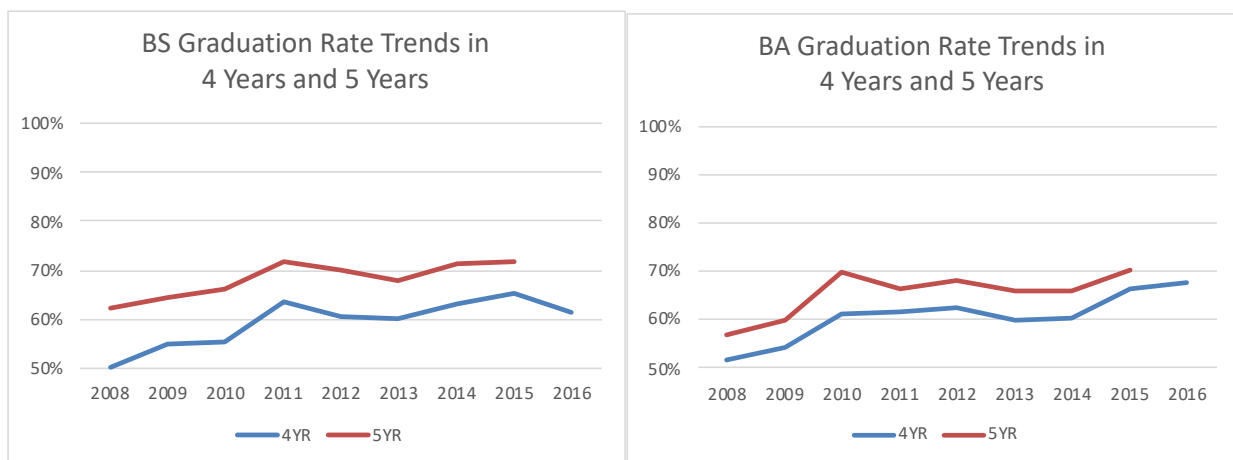




The percentages of students graduating with a B.S. degree in 4 years and 5 years were most recently 61% and 72% respectively (2016 and 2015 cohorts). The percentages of students graduating with a B.A. degree in 4 years and 5 years were most recently 68% and 70% respectively (2016 and 2015 cohorts). Only 1-3% more students graduate from either program after 5 years. In the most recent years, 7% more B.A. students than B.S. students graduated within 4 years, however this difference disappeared in the fifth year.

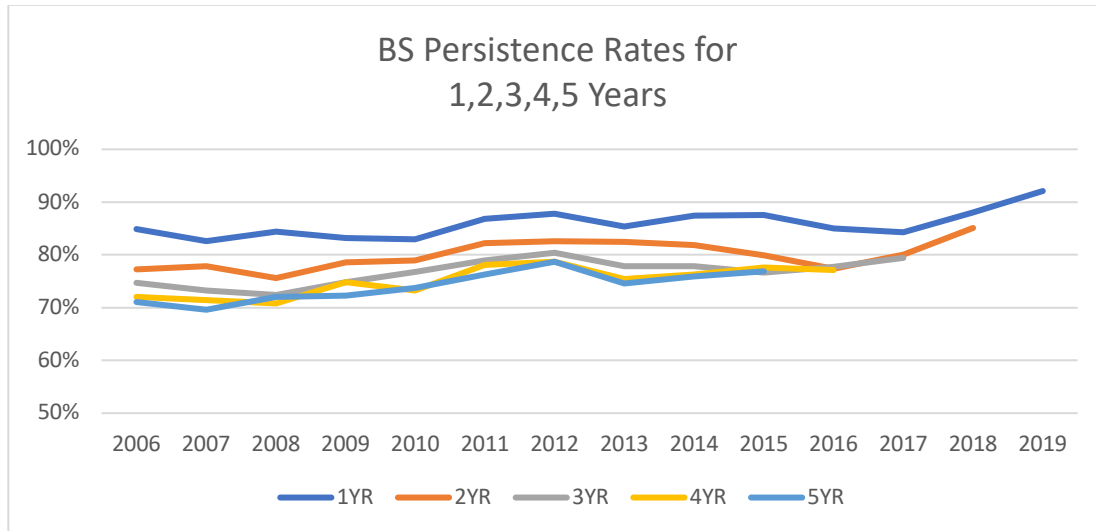


In 2011, the 4-year B.S. graduation rate jumped from 55% to 64%, and has remained at or above 60% ever since. In the same year, the 5-year graduation rate jumped from 66% to 72% and has remained in the 68%-72% range ever since. The four-year and five-year graduation rates for the B.A. degree have similarly increased considerably from lows of 52% and 57% (both in 2008) to the most recent record highs of 68% and 70% respectively.

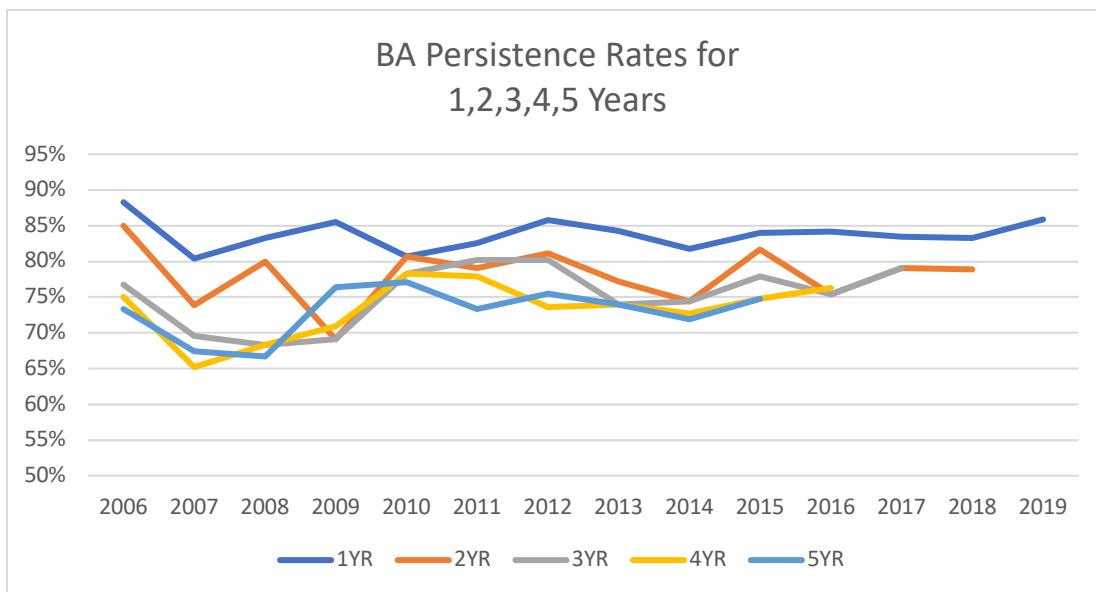




Persistence: The one-year and two-year persistence rates (graduates + retained students) for students in the B.S. program have increased 4% and 5%, to 92% and 85% respectively, in the latest cohorts (2019 and 2018 cohorts). These one-year and two-year persistence rates are the highest in the record covered by this study. Three-year, four-year, and five-year persistence rates are in the range of 77%-79% and have not changed as much historically. In general, most attrition occurs in years 1 and 2, so we hope to see the historic persistence levels for current one-year and two-year cohorts remain high as these students move through the curriculum.



In recent years, the persistence rates for students in the B.A. program have remained more-or-less flat, with one-year persistence rates in the mid 80% range and longer persistence rates in the mid to high 70% range. In years prior to 2010, long range persistence (>3 years) was as low as the mid 60% range, however beginning in 2010 long-term persistence increased to the mid to high 70% range.





College Survey of ICS Seniors

The College of Natural Sciences recently released the results of an internal survey of seniors in the B.S. and B.A. programs (surveys conducted in Fall 2016, 2017, and 2018). Eighty-three percent of B.S. students and 85% of B.A. students responded “Yes” to the question “Would you recommend your department to someone looking for a good undergraduate education?” Ninety-three percent of B.S. students and 90% of B.A. students responded “Yes” to the question “Do you feel that your department has met your needs?”

In answer to the question “What did you like most about our department?”, the most common answer for both B.S. and B.A. students was the professors. The second most common answer was the advising program, and the third most common answer for B.S. students was the curriculum. In answer to the question “What did you like least about our department?”, the most common answer for both B.S. and B.A. students was the lack of course availability. The second most common answer for B.S. students was the professors, while the second most common answer for B.A. students was the curriculum. B.A. students were also dissatisfied with the degree requirements.

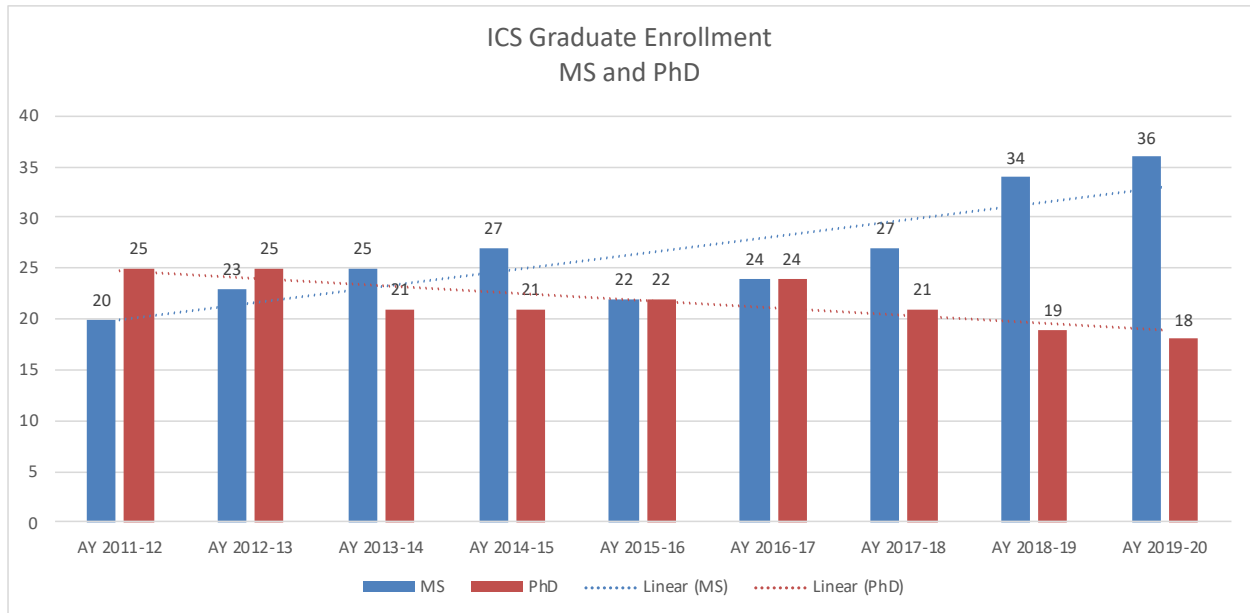
What did you like the most about our department?		
	B.S. (n=72)	B.A. (n=22)
Professors	29.2%	31.8%
Advising	16.7%	22.7%
Curriculum	13.9%	n/a
What did you like the least about our department?		
	B.S. (n=53)	B.A. (n=20)
Course Availability	24.5%	30.0%
Curriculum	11.3%	25.0%
Degree Requirements	7.5%	20.0%
Professors	20.8%	5.0%
Course Topics	17.0%	n/a





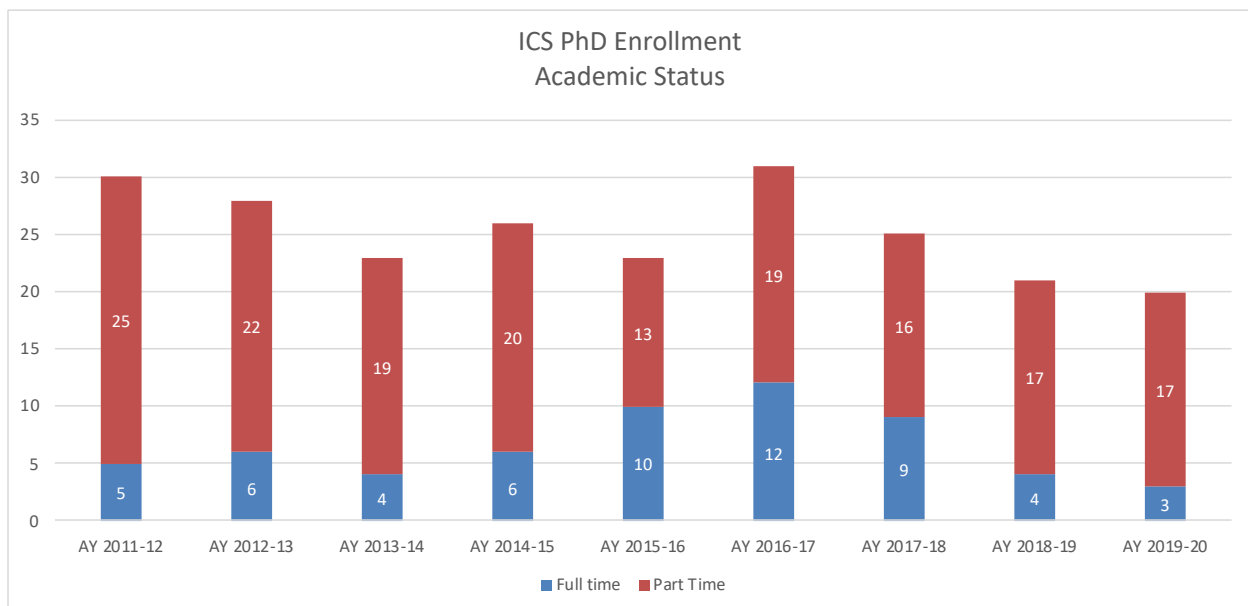
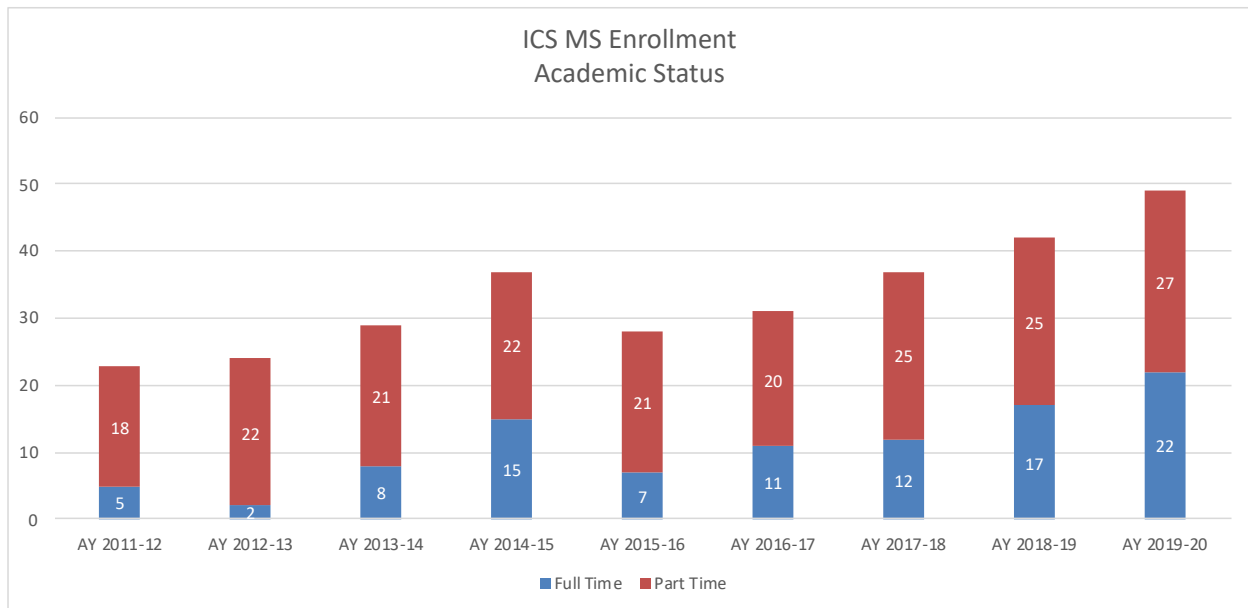
Graduate Programs

Enrollment: In Academic Year 2019-2020, 36 students were enrolled in the Computer Science M.S. program and 18 students were enrolled in the computer science Ph.D. program. In this report period (9 years), the ratio of M.S. students to Ph.D. students has gone from being approximately equal in 2011-2013 to now having twice as many M.S. students as Ph.D. students. This is due to both a large increase in the number of M.S. students and a small decrease in the number of Ph.D. students.



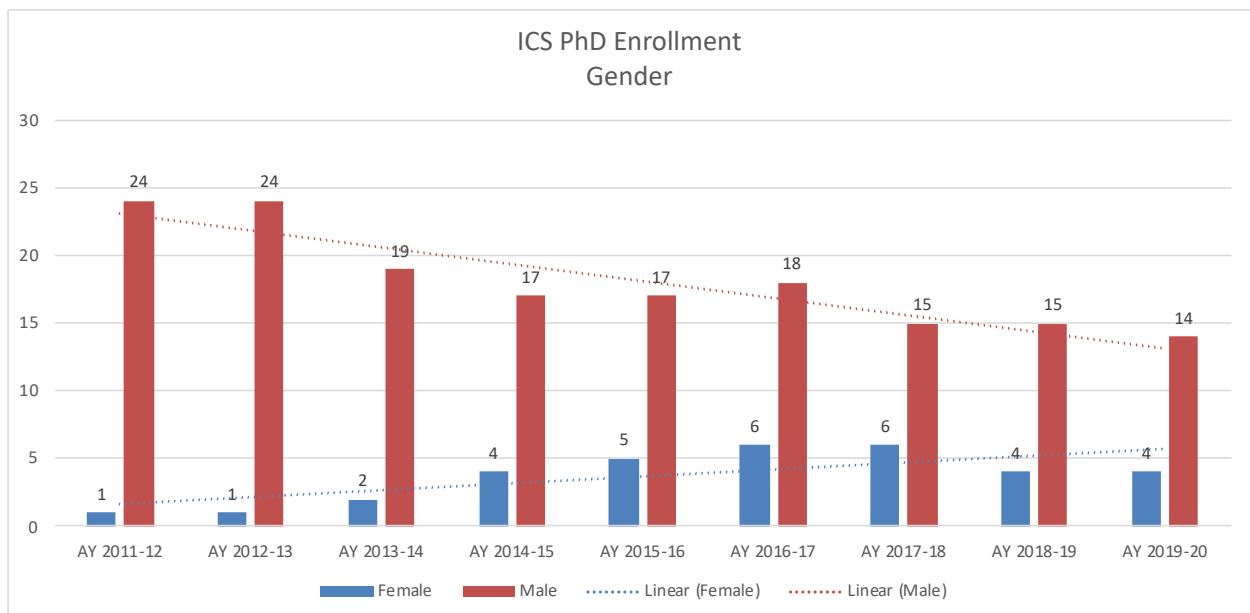
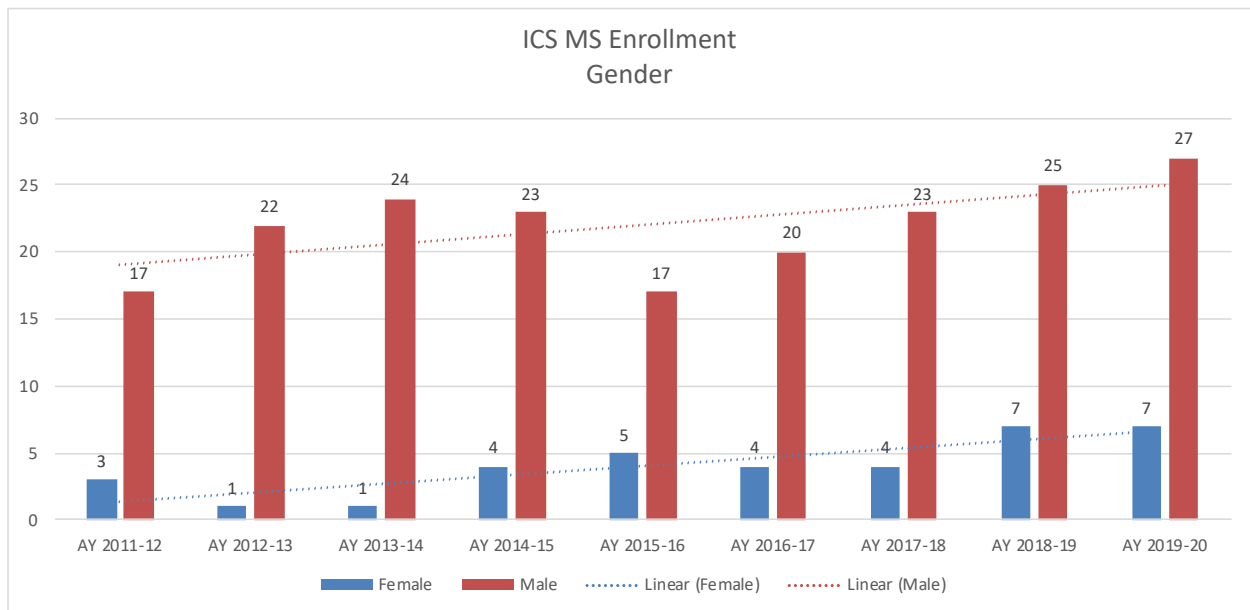


Approximately 45% of M.S. students are full time. This percentage has increased over the last several years from a low of 9% in AY 2012-13. This is made possible by the availability of research and teaching assistantships for students at the masters degree level. In contrast, only 15% of Ph.D. students are full time, down from a high of 44% in 2015-2016. While Ph.D. students have priority for assistantships, many move to part-time status while finishing their dissertations.



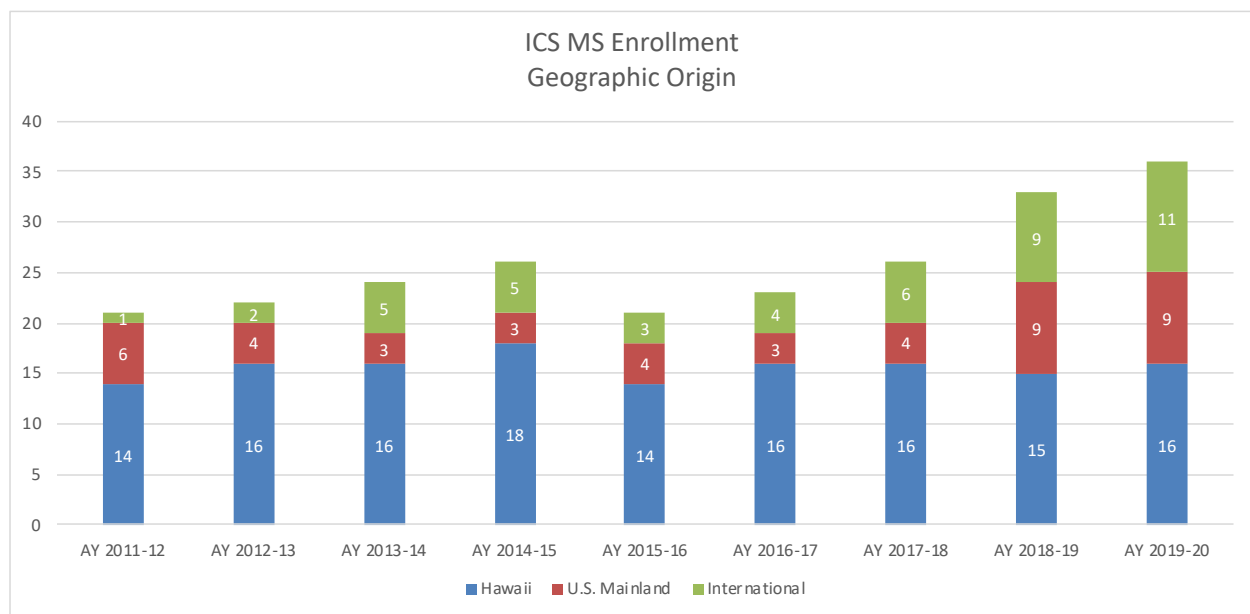


In AY 2019-2020, approximately 21% of M.S. students and 22% of Ph.D. students were female. The percentage of females in both graduate programs has increased steadily from lows of 4% (in 2013 for the M.S. and 2011-2013 for the Ph.D.) such that now the percentage of females is consistent with national norms.

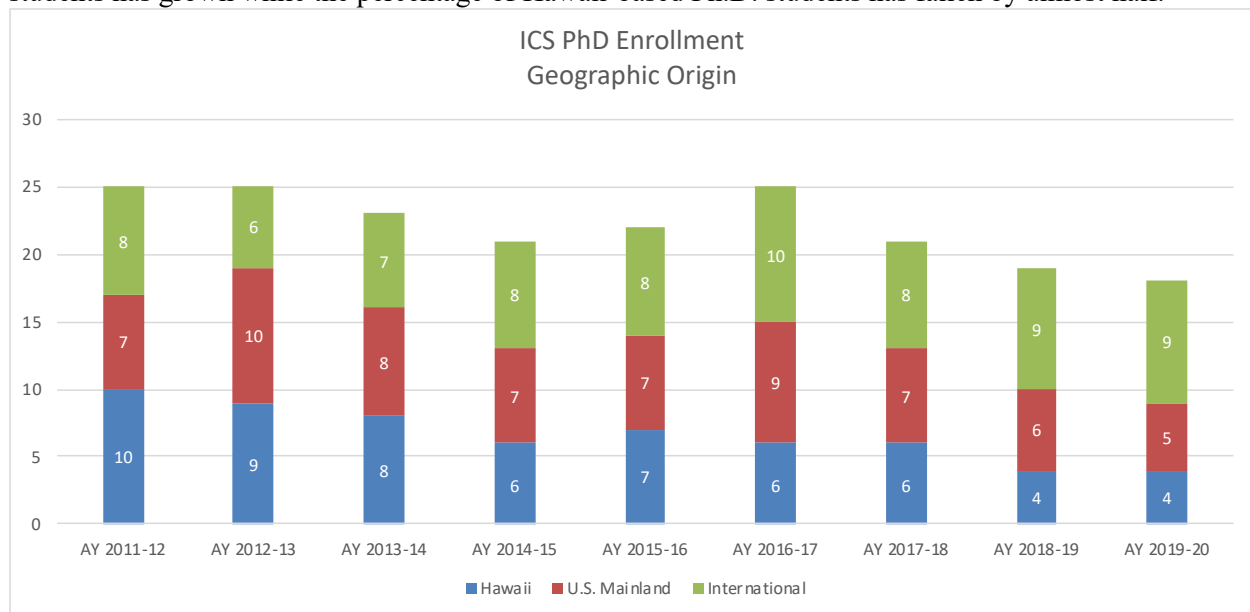




In AY 2019-2020, the percentages of M.S. students from Hawaii, the U.S. Mainland, and International were 44%, 25%, and 31% respectively. The representation of M.S. students from out of state has increased consistently over the last several years, and in AY 2018-2019, it surpassed 50% for the first time.

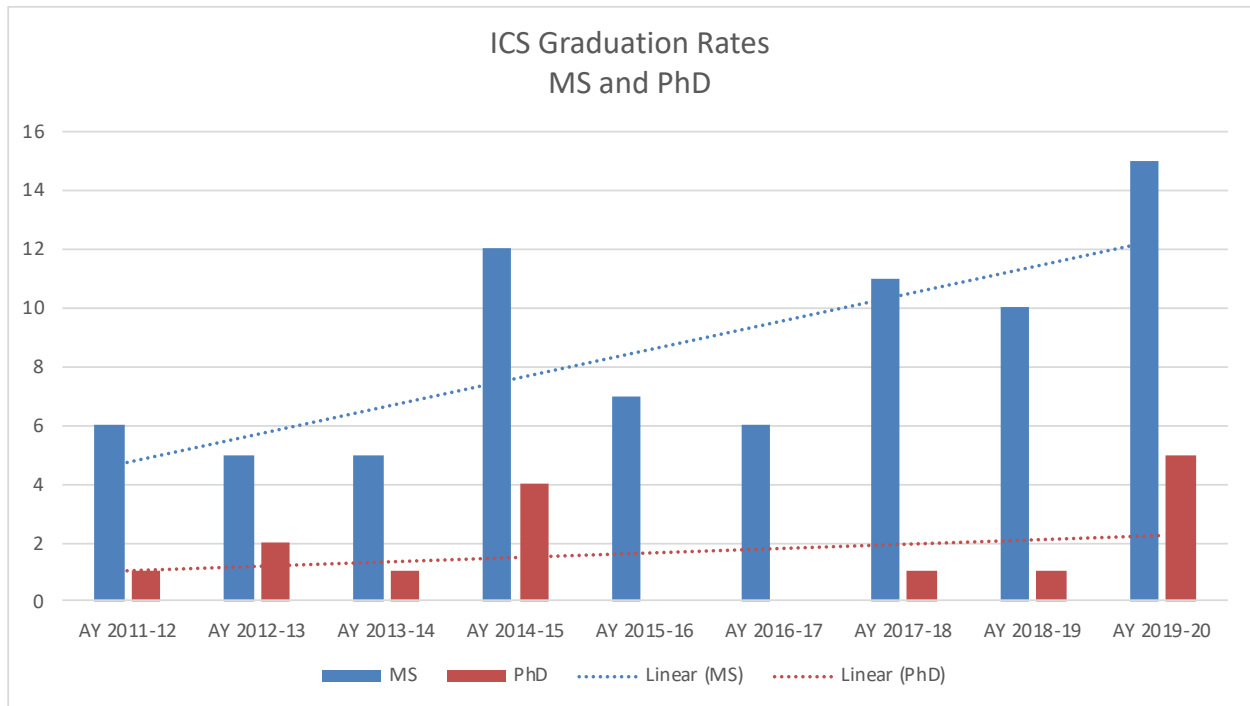


In AY 2019-2020, the percentages of Ph.D. students from Hawaii, the U.S. Mainland, and International were 22%, 28%, and 50%, respectively. During the study period, the percentage of international Ph.D. students has grown while the percentage of Hawaii-based Ph.D. students has fallen by almost half.





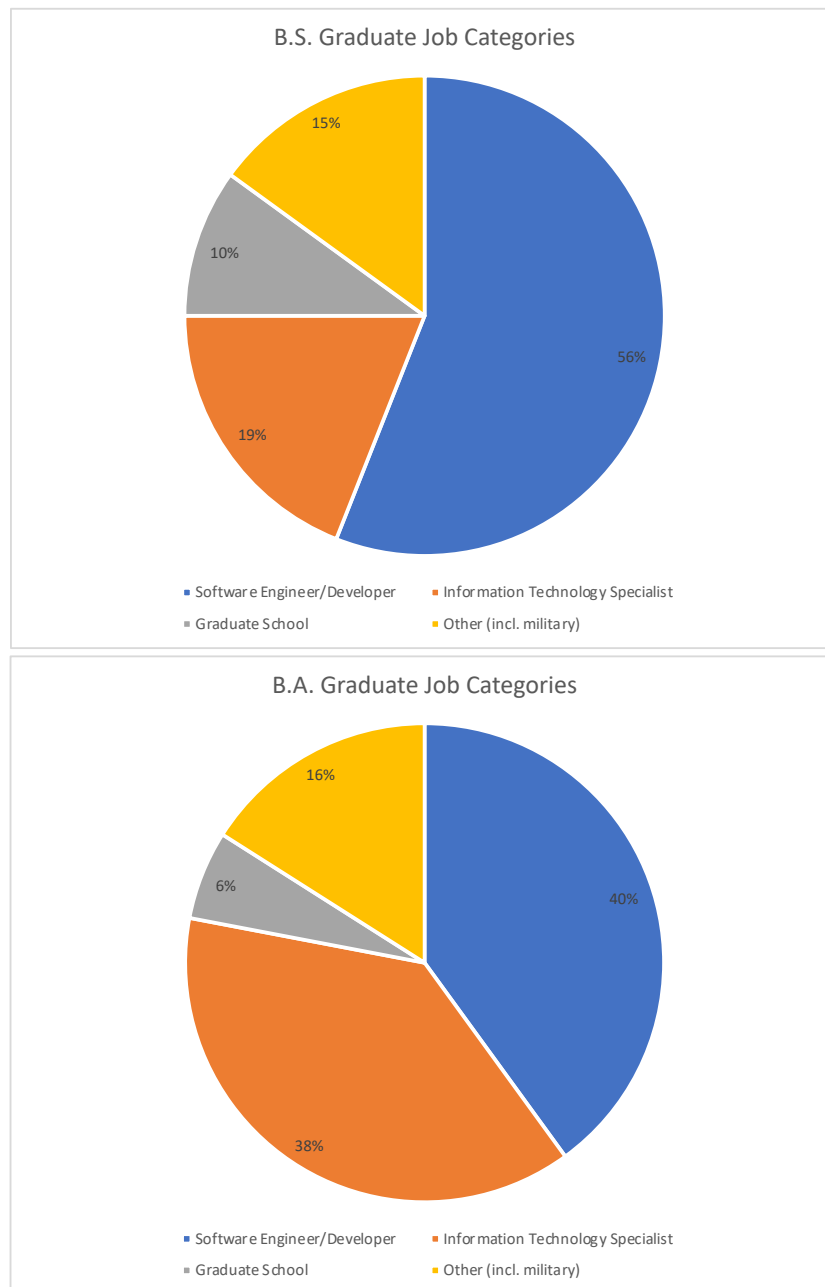
Graduation: In Academic Year 2019-2020, 15 students received the M.S. in Computer Science and 5 students received the Ph.D., both record numbers. Three of the master's degree recipients were female. All Ph.D. recipients were male.

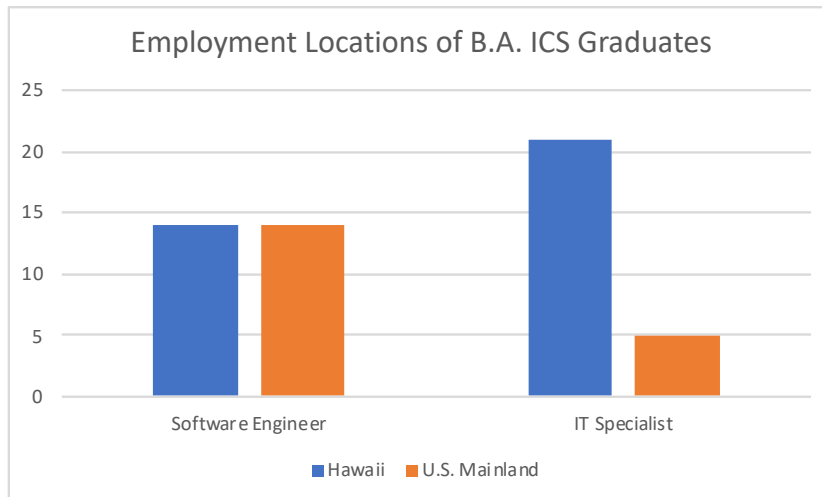
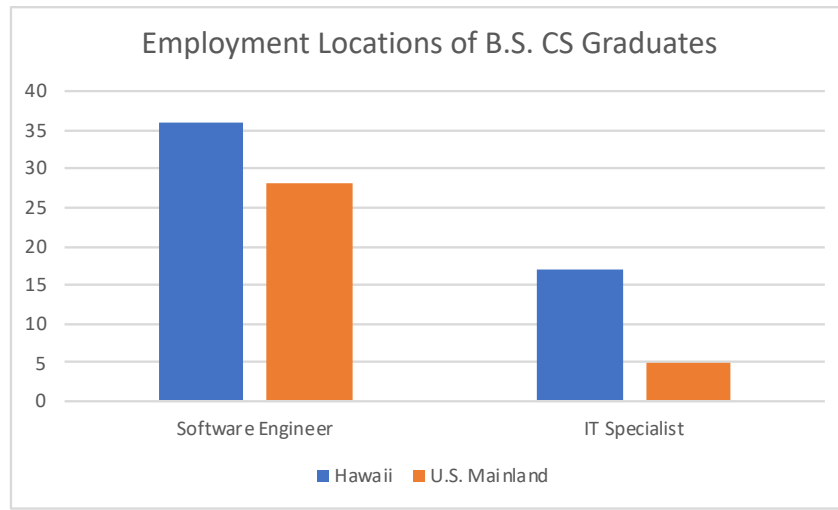




Job Survey of Recent Graduates

In preparation for this self-study, a search was conducted to determine the employment status of all 182 students from the B.S. program and all 92 students from the B.A. program who graduated during the period of Spring, 2016 to Spring, 2019 (inclusive). It was possible to determine the employment status of 115 B.S. graduates (63%) and 69 B.A. graduates (75%), which is the population reported on here. We report data separately for graduates working as Software Engineers/Developers versus graduates working as Information Technology Specialists.





Self-reported job titles that we categorized as “Software Engineer/Developer” are:

- Software Engineer
- Program Manager
- Implementation Consultant
- Web Designer/Developer
- Cybersecurity Analyst

Self-reported job titles that we categorized as “IT Specialist” are:

- IT Specialist/Consultant
- Network Support
- Systems Engineer/Analyst
- Data Analyst
- Communications Technician





At this time, 56% of the graduates of the B.S. program that we were able to track are employed as Software Engineers/Developers, 19% are employed as Information Technology Specialists, 10% are in graduate school, and 15% are employed in another field (or are serving in the military). For the B.A. graduates that we were able to track, 40% are employed as Software Engineers/Developers, 38% are employed as Information Technology Specialists, 6% are in graduate school, and 16% are employed in another field (or are serving in the military).

The majority of graduates who earned the B.S. degree are working in Hawaii – 56% of software engineers/developers, and 77% of IT Specialists. A large majority of graduates who earned the B.A. degree and who are working in IT are employed in Hawaii (81%). B.A. graduates who are working as software developers/engineers are evenly split between Hawaii (50%) and the U.S. mainland (50%).

The ICS graduates we tracked who are working in Hawaii are employed by 47 different companies/institutions. The local companies/institutions employing the most graduates in our sample are:

- University of Hawaii (11)
- eWorld (7)
- State/City/ County Government (6)
- Decision Research Corporation (5)
- Hawaii Electric Company (4)
- Techmana - Hawaii Technology Consulting (3)
- Datahouse (2)
- Banks (BoH and ASB) (2)

Other notable local employers of graduates in our sample are:

- Booz Allen Hamilton
- Naval Information Warfare Center
- Pacific Defense Solutions
- SPAWAR - Space and Naval Warfare Systems Command
- Lockheed
- Oceanit

The ICS graduates we tracked who are working outside of Hawaii are employed by 23 different companies/institutions. The out-of-state companies employing the most graduates in our sample are:

- Microsoft (7)
- Amazon (2)
- Google (2)
- IBM (2)

Other notable out-of-state employers of graduates in our sample are:

FireEye	Prudential
Ford Motor Company	Roku
Jaguar Design	Scientific Research Corporation
Northrop	VISA
Prudential	





Research

The ICS Department is the state's only Research I computer science department. We value this mandate and strive to increase our visibility as a research department.

Labs and Research Groups

The ICS Department organizes research around self-forming labs and research groups. Notable labs and research groups that are currently receiving external funding or have in the recent past, consistently produce significant journal and conference talks, and support graduate students and undergraduate researchers include:

- AlgoPARC: Algorithms and Parallel Computing
<https://algotarc.ics.hawaii.edu/>
- ASECO: Adaptive Security and Economics
<http://www.asecolab.org/>
- CORG: Concurrency Research Group
<https://henricasanova.github.io/>
- CSDL: Collaborative Software Development Group
<http://csdl.ics.hawaii.edu/>
- HICHI: Hawaii Human-Computer Interaction Lab
<http://manoa.hawaii.edu/hichi/>
- HINT: Hawaii Interdisciplinary Neurobehavioral and Technology (HINT) Laboratory
- LAVA: Laboratory for Advanced Visualization and Applications
<https://www.lavaflow.info/>
- LILT: Laboratory for Interactive Learning Technologies
<http://lilt.ics.hawaii.edu/>
- Sadowski Lab (Machine Learning and Data Science)
<https://www2.hawaii.edu/~psadow/>

Ranking and Reputation

The ICS Department ranked as follows in the Times Higher Education World University Rankings for computer science:

Year	Rank	N Schools
2021	501-600	827
2020	301-400	749
2019	401-500	684
2018	251-300	300

In 2018, the ICS Department ranked 119 out of 188 schools in the *U.S. News and World Report* Best Graduate Schools in Computer Science.

According to CSRankings.org, which ranks 185 U.S. institutions in 26 subfields of computer science, using strict metrics based on publication data from select venues drawing from dblp and Google Scholar, the ICS department ranks at the 32nd percentile overall (125 out of 185 participating schools). The ICS Department





appears in 10 of the 26 subfields subfields (up from 7 two years ago) as follows (data shows the ICS Department rank followed by the number of universities that ranked in that category in parentheses):

	Rank	Nschools	Percentile rank
Overall	125	185	32
Logic and Verification	27	63	57
Human-Computer Interaction	66	129	49
Software Engineering	64	106	40
High Performance Computing	76	111	32
Machine Learning and Data Mining	111	146	24
Algorithms and Complexity	82	95	14
Computer Architecture	77	86	10
Programming Languages	83	91	9
Vizualization	85	90	6
Design Automation	89	89	0

While ICS is proud of these rankings, close scrutiny of the data shows that they are due to nine faculty members. The number of faculty members contributing to each ranking is as follows (in some cases, a faculty member is in more than one category):

	N Faculty
Logic and Verification	2
Human-Computer Interaction	3
Software Engineering	1
High Performance Computing	2
Machine Learning and Data Mining	1
Algorithms and Complexity	1
Computer Architecture	1
Programming Languages	1
Vizualization	1
Design Automation	1

While some faculty do not contribute to this metric because they publish outside of venues tracked (e.g. bioinformatics research in biology and medical venues, evolutionary computing and sustainable computing in physics and energy venues), many faculty members choose less well-established publication or conference venues, which reduces the visibility and prestige of the department's research.



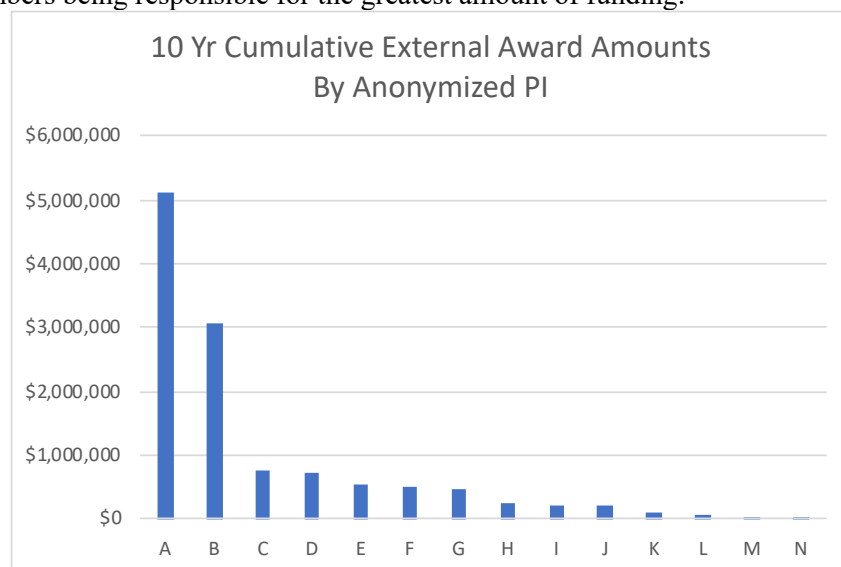
External Funding

The trend for receipt of funding with ICS faculty as PI or co-PI has accelerated in recent years. The ICS Department exceeded \$2M in new external awards for the first time in 2020. The number of new awards per annum has also increased significantly:

Start Date	Amount	N Awards
2010	\$147,419	1
2011	\$1,191,838	3
2012	\$25,000	1
2013	\$1,424,043	2
2014	\$640,332	4
2015	\$3,877,325	7
2016	\$186,041	5
2017	\$638,331	7
2018	\$1,245,196	11
2019	\$1,248,514	8
2020	\$2,660,868	9

Aggregated over the last decade, grant funding to researchers in the ICS Department has come primarily from three sources: The National Science Foundation (39%), NASA (23%), and in collaboration with other colleges and universities as cooperative projects (23%). Funding from the U.S. Department of Defense has been modest (4%).

Over the 10-year period examined for this report, 14 faculty members received funding in some amount, however, in general the amounts have been modest. The funding profile for ICS has a long tail, with one or two faculty members being responsible for the greatest amount of funding:





Previous External Review

In Fall, 2019, the university administration arranged an external review of the ICS program and the Computer Engineering program in the College of Engineering. The report from that review made several recommendations for ICS:

- Increase the number of Computer Science graduates from UH Mānoa.
- Increase the employability of UH Mānoa Computer Science graduates, with emphasis on local private sector and public sector employers.
- Increase interdisciplinary research collaboration by Computer Science faculty.
- Increase engagement with external public sector and private sector entities.
- Increase the faculty productivity in terms of PhD production, research expenditures, etc.
- Increase entrepreneurial activities of CS faculty and students.

The external review also proposed options for ICS in which the program might be reorganized into a computer science component located in the College of Engineering and an information science component remaining in the College of Natural Sciences or relocating to the College of Social Sciences.

In response to the external review, a “change team” was organized within the department and two documents were produced, one with goals for modifying the undergraduate and graduate student experience and another for improving program and faculty assessment. The COVID-19 crisis has delayed action on aspects of these proposed changes, but many are underway:

- An external advisory board was formed to help guide future departmental actions and connect ICS with the local business, defense, and government sectors. The advisory board membership is listed in Appendix C.
- An annual student survey has been designed and was disseminated for the first time in Spring 2021.
- A curriculum review team has embarked on program changes to streamline the ICS curriculum and coordinate more closely with offerings in the College of Engineering
- Assessment instruments for two of the early ICS core courses, ICS-111 and ICS-141, are being developed.
- A capstone requirement was approved by faculty and several discussions with external representatives from local government and industry are ongoing.
- Implementation of the College of Engineering’s “Vertically Integrated Projects” (VIP) program in ICS is in development with new Sophomore-level and Junior-level project course descriptions ready for consideration in Fall 2021.
- Boot camps for Data Science and for Creative Computational Media are being designed for Summer 2023.
- A STEM pre-academy and Native Hawaiian Science and Engineering Mentorship Program for middle-school students are being planned this summer to be offered in Fall 2021.





With regard to potential reorganization:

- Reorganization meetings were held with Library and Information Science faculty and the newly forming School of Communication and Information. A plan has been completed to move LIS to the new School, possibly as early as Spring 2022.
- Several meetings were held between ICS change team members, the ICS Chair, representatives from the College of Engineering, and the Dean of Engineering in order to identify synergies and collaborative opportunities. In addition, a plan was developed and agreed to such that, if a reorganization takes place:
 - The ICS department remains together and will not be combined with any other department in the College of Engineering.
 - The ICS department maintains its autonomy with regard to hiring, promotion, and other personnel matters.
 - No faculty member who wishes to move with the department will be denied or excluded.

Collaborative Projects and New Directions

In addition to actions taken in response to the 2019 review, the ICS Department participates in, and is planning many collaborations across the Mānoa campus. Examples include:

- **Data Science:** The Hawaii Data Science Institute (HI-DSI) is a University of Hawai‘i system-wide effort to support data science education, collaborative research and partnerships with industry. The ICS Department’s two newest faculty members, Mahdi Belcaid and Peter Sadowski, serve as researchers in collaboration with the HI-DSI. With their help, ICS developed the Data Science Track within the B.S. program and the Data Science Certificate.
- **Computer Engineering:** The ICS Department and the Computer Engineering (CE) program in the College of Engineering have a joint B.S. degree in Computer Engineering. This degree path combines courses from both programs. Together, we are also working towards offering a 5-year Bachelor’s and Master’s (BAM) pathway to the M.S. degree in Computer Engineering.
- **Cybersecurity:** Professors Dusko Pavlovic in ICS and Yingfei Dong in the College of Engineering are the leads in an interdisciplinary research and education effort in cybersecurity. Under their leadership, the University of Hawaii at Mānoa is recognized by the National Security Agency and the Office of Homeland Security as a National Center of Academic Excellence in Research (CAE-R) in Cybersecurity. This designation has just been continued for the period 2019-2024.

In collaboration with ICS and Engineering, several students from both programs have been involved with the CyberCorps Scholarship for Service program (2017-2022)

The ICS Department has embarked on some significant new initiatives:

- **RadGrad:** (<https://www.radgrad.org>) Professor, and former Associate ICS Chair, Philip Johnson has embarked on a project to radically change the undergraduate experience by balancing coursework with project-oriented extracurricular activities and by linking education more closely





with career goals. The RadGrad project has recently received significant funding from the National Science Foundation.

According to the project website: “The fundamental goal of the RadGrad Project is to provide students, faculty, and advisors with an alternative perspective on the undergraduate degree program---which traditionally boils down to a single kind of activity (coursework) and a single metric for success (grade point average). Our alternative perspective is called the Degree Experience, and it gives first class status to both curricular activities (courses) and extracurricular activities (discipline-oriented events, activities, clubs, etc.). To establish the first-class status of extracurricular activities, the Degree Experience perspective replaces GPA as the single metric for success with a three-component metric...that assesses student development with respect to Innovation, Competency, and Experience. Each student's Degree Experience also includes a representation of their disciplinary interests and career goals that helps them assess the relevance of potential curricular and extracurricular activities.”

Success metrics for RadGrad will include increased engagement and retention, a curriculum-wide switch to project-based learning and portfolio-ready class projects, and greater success at smoothly placing students in careers.

- **Capstone Requirement:** The goal of the recently approved capstone course requirement is to give students experience with a large-scale, team-oriented software project that requires integration of material learned across multiple courses. In addition to in-house projects, the capstone requirement may be satisfied by participation of students on year-long team projects as part of internships. Completion of the capstone requirement will guarantee that our students have the critical skills of creating and meeting project requirements and milestones, factoring a project into stages and deliverables, assigning teams and assessing progress, integrating modules into a final product, managing a software project using current project-management tools, methods, and environments, and presenting goals and final project outcomes to relevant stakeholders.
- **Data Science Track:** In 2019, the ICS Department initiated a new track for students pursuing the B.S. degree. The Data Science track exposes students to the mathematical and analytical foundations necessary for a career in data science. This new track is in addition to the existing Security Science track, which exposes students to the foundational principles necessary for a career in security-related areas. In both cases, new courses were developed to support the tracks.
- **New Certificate in Creative Computational Media:** The ICS department partnered with the Academy for Creative Media, the Department of Theatre of Dance, and the Department of Electrical Engineering to develop and offer an Undergraduate Certificate in Creative Computational Media. The objective is to provide students and/or professionals with training necessary to enter into job markets relating to, but not limited to: video game design and development, digital film production and special effects, eSports, new media theatre and dance performance, movement-based media art installation, interactive public exhibit design such as for museums or marketing/advertising. The first students will begin in Fall 2021.





- **New Certificate in Data Science:** The ICS department partnered with HI-DSI to develop a certificate for students in multiple disciplines to gain expertise in data science and machine learning methods. The proposal will be voted on by the Faculty Senate in Fall 2021.
- **Computational Science:** In recognition of the adoption of computational modeling and data analytics in multiple disciplines, the ICS Department is exploring the idea of creating a program in Computational Science. Computational Science would involve partnering with other departments to provide computing and data-science training necessary for practitioners within the discipline, without needing to complete all of the requirements of a dual-degree. For example, a computational biologist and a computational linguist might require a common-core of training with computing principles, a computing language, and data analytics, but would not require deep knowledge of algorithms or software engineering. The Computational Science option would allow them to pursue the requirements of their home discipline, while at the same time providing relevant training and knowledge in computation, data handling, and analytics. A Computational Science program could also provide a common “home base” for students and researchers in multiple disciplines.

Reflections

Computer Science is a critical, high-demand discipline. At the same time, the definition of computer science is elusive and undergoing constant change. The ICS Department at the University of Hawaii at Mānoa was founded at a time when the *fundamental science* aspect of the discipline was paramount and *applications* and *users* of computing technologies were few. At the present time, the ICS Department is feeling the strain of meeting the needs of a growing student population and growing demand for innovative application-oriented training, while at the same time meeting the responsibilities of providing the fundamental knowledge expected of educated computer scientists.

The ICS Department acknowledges several challenges, many of which are highlighted in this self-study. We have undertaken steps to address several, and we welcome the evaluators’ suggestions about how these matters might be prioritized and approached:

- **Growth of student enrollment but not in faculty size.** Enrollment in the undergraduate B.S. degree program is dramatic, however, the size of the ICS faculty has not changed in many years. This means that ICS class sizes are increasing and that many potential areas of computer science, especially new areas, are not being covered by our curriculum. There are two solutions to this problem: new positions and retraining. With regard to new positions, the ICS Department has submitted annually ideas for faculty positions in emerging areas and in areas related to the university’s strategic plans. In response, we have been able to make a small number of new hires to replace retiring faculty, however our faculty has not grown. With regard to retraining, the university encourages faculty on sabbatical to use this opportunity to gain new skills. The Department Chair could prioritize this goal in judging sabbatical applications in the future.
- **Top-heavy faculty.** A healthy faculty includes Assistant Professors who are at the beginning of their careers but at the top of their game. New professors have been enculturated in an academic world that values high publication rates and competitive funding participation. Only by increasing the proportion of Assistant Professors can the culture of the department change. A related issue is





how to better utilize the wisdom and experience of senior faculty who are not engaged in proposal writing or lab building.

- **Purpose of the B.A. degree.** Enrollment in the B.A. program is shrinking at the same time that enrollment in the B.S. program is increasing. Many faculty members believe that this is due to recent changes in the curriculum, strengthening of the math requirements in particular, that made the two degrees almost indistinguishable. We will begin discussions to bring the B.A. degree back into line with its original purpose, which was to serve a population that will not necessarily become computer scientists, but who will have computation-related careers in other fields, or who will be primarily responsible for application-level issues and concerns. One problem with this approach is that the B.A. can easily become perceived as a “watered-down” version of the B.S., and therefore less desirable. It is important, then, to make it clear to students and to employers what unique skills the B.A. degree will confer. Another possibility is to “re-brand” the B.A. degree to be “Information and Computational Science,” and to seek a different potential student audience in fields aligned with computing.
- **Size and success of the Master’s degree program.** The M.S. degree program are very small for a university the size of the University of Hawaii. In addition, the goal of the M.S. degree is not well defined. One of the most significant challenges for the ICS Department is to develop a more diverse and nuanced master’s curriculum tied closely to the needs of employers. The Master’s program should serve returning students and individuals seeking retraining or intending to refresh a professional skill. To address this need, the ICS Department has requested hiring a faculty specialist who is focused on professional programs and external relations. We hope to build professional and applied master’s-level training with instructional faculty who are able to commit their full attention to these professional training needs.
- **ABET accreditation:** Several years ago, the ICS Department began the process of obtaining ABET accreditation. The establishment of the capstone project requirement and the strengthening of the math requirements for undergraduates were significant positive changes toward meeting ABET requirements. However, the changing nature of ABET requirements, and unanticipated ripple effects caused by creating the data-science and security-science tracks, have placed ABET accreditation on hold. We are now considering pursuing ABET as part of the B.A. degree realignment and may seek accreditation of a general version of the undergraduate degree only.
- **Research versus application:** The ICS department strives to provide students with the fundamentals necessary for a deep knowledge of computer science. This is reflected in a core curriculum that stresses the mathematical, theoretical, and foundational principles of the discipline. This has led to criticism that students are not being exposed to emerging practical tools and methods, and to a perception that students do not receive enough practical programming experience. We are addressing this first and foremost with the new capstone requirement. The capstone requirement is aimed directly at assuring that students do not graduate without the practical programming, project management, and teamwork skills that will be necessary in any workplace situation. The ICS department is also working toward designing a more modular curriculum, which would also apply at the master’s level, in which students and returning professionals can receive credit for shorter units than full-semester courses, and then combine units





to receive enough credit for full courses, certificates, and even degrees. This latter model is difficult to implement in a traditional, semester-oriented academic institution.

- **Projection into the community:** We were pleased to find that our students are finding jobs in both the local community and on the U.S. mainland. The ICS Advisory Board will help to maintain external relations with employers. Discussions are ongoing with multiple local private and military employers to engage our students in internships related to the capstone project.
- **Relevance to the local defense industry:** The military, intelligence community, and defense industry have a significant presence in Hawaii. Of course, they utilize considerable numbers of computer scientists and other technical personnel related to the computing field. They also require training and retraining of their personnel who are on the island. The list of employers of our students shows that we do not have a strong relationship with this constituency. Again, we are counting on the capstone internship outreach to strengthen the ICS tie with this sector.
- **Increased research funding and enhanced Ph.D. program:** At this time, we have a handful of labs that consistently bring in funding, train Ph.D. students in research, and actively participate in the research community. Many faculty members do not feel that it is important to obtain funding, or even to publish in venues that would bring greater recognition and, thereby, attract more and better Ph.D. students. Changing this may require a cultural shift that will take time. Hiring new faculty at the Assistant Professor level, rewarding and enabling proposal writing, and rewarding high-profile publication and conference participation should become a regular part of the administration of the ICS department.
- **Alumni outreach:** The ICS program has alumni throughout Hawaii, the U.S. mainland, and internationally. A focused effort to keep alumni involved with the department, and to involve local alumni with current students, has not previously been a priority.

Conclusion

The ICS program at the University of Hawaii is at a crossroads. With so many senior faculty members, a generational change is likely to take place over the next five years. With appropriate strategic vision and tactical planning, the ICS department aims to transform into a highly productive research environment, a relevant training ground for future computer scientists and other professionals working in computing-related disciplines, and a resource for returning professionals to gain up-to-date refresher knowledge. We are currently taking steps to make this transition with the new capstone requirement, with plans for updating our labs to active learning spaces, and with strategic development of a professional master's degree program and better external relations. We are hopeful that the additional external evaluation can help us develop this vision, and provide our administrators with the confidence to help us move forward.

