Fiscal Unit/Academic Org	Statistics - D0694
Administering College/Academic Group	Arts and Sciences
Co-adminstering College/Academic Group	
Semester Conversion Designation	New Program/Plan
Proposed Program/Plan Name	Statistics
Type of Program/Plan	Undergraduate bachelors degree program or major
Program/Plan Code Abbreviation	STAT-BS
Proposed Degree Title	Bachelor of Science

Credit Hour Explanation

Program credit hour requirements		A) Number of credit hours in current program (Quarter credit hours)	B) Calculated result for 2/3rds of current (Semester credit hours)	C) Number of credit hours required for proposed program (Semester credit hours)	D) Change in credit hours
Total minimum credit hours required for completion of program				115	
Required credit hours offered by the unit	Minimum			34	
	Maximum			40	
Required credit hours offered outside of the unit	Minimum			26	
	Maximum			32	
Required prerequisite credit hours not included above	Minimum			0	
	Maximum			0	

Program Learning Goals

Note: these are required for all undergraduate degree programs and majors now, and will be required for all graduate and professional degree programs in 2012. Nonetheless, all programs are encouraged to complete these now.

Program Learning Goals

- Students will be proficient at exploratory data analysis using graphical and computational tools.
- Students will understand mathematical concepts relevant to statistical theory, and will be adept at applying these concepts to statistical models for data, such as those arising in the physical, biological, and social sciences, and in business.
- Students will be able to assess whether hypotheses are supported by data and to quantify uncertainty in parameter estimates and models.
- Students will be able to develop, fit, assess, and compare statistical models in a formal probabilistic framework.
- Students will be able to communicate the results of a statistical analysis in both oral and written formats, in a manner appropriate to the audience.

Assessment

Assessment plan includes student learning goals, how those goals are evaluated, and how the information collected is used to improve student learning. An assessment plan is required for undergraduate majors and degrees. Graduate and professional degree programs are encouraged to complete this now, but will not be required to do so until 2012.

Is this a degree program (undergraduate, graduate, or professional) or major proposal? Yes

Does the degree program or major have an assessment plan on file with the university Office of Academic Affairs? No

DIRECT MEASURES (means of assessment that measure performance directly, are authentic and minimize mitigating or intervening factors)

Classroom assignments

- Embedded testing (i.e. specific questions in homework or exams that allow faculty to assess students' attainments of a specific learning goal)
- Other classroom assessment methods (e.g., writing assignments, oral presentations, oral exams)

INDIRECT MEASURES (means of assessment that are related to direct measures but are steps removed from those measures)

Surveys and Interviews

- Student survey
- Student evaluation of instruction

Additional types of indirect evidence

- Job or post-baccalaureate education placement
- Curriculum or syllabus review

USE OF DATA (how the program uses or will use the evaluation data to make evidence-based improvements to the program periodically)

- Analyze and discuss trends with the unit's faculty
- Analyze and report to college/school
- Make improvements in curricular requirements (e.g., add, subtract courses)
- Make improvements in course content
- Make improvements in course delivery and learning activities within courses
- Periodically confirm that current curriculum and courses are facilitating student attainment of program goals

Program Specializations/Sub-Plans

If you do not specify a program specialization/sub-plan it will be assumed you are submitting this program for all program specializations/sub-plans.

Pre-Major

Does this Program have a Pre-Major? No

Attachments

- Statistics-Chair-Support-Letter.pdf: Statistics Chair's Letter

  (Letter from Program-offering Unit. Owner: Lee,Yoonkyung)
- Concurrence-Letters.pdf: Concurrence Letters

  (Support/Concurrence Letters. Owner: Lee,Yoonkyung)
- StatisticsMajorProposal.pdf: Program Proposal

  (Program Proposal. Owner: Lee,Yoonkyung)
- Structure of Stats BS V2.docx: Structure of Stats Major

  (Other Supporting Documentation. Owner: Lee,Yoonkyung)

Comments

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Lee,Yoonkyung	09/04/2017 09:25 PM	Submitted for Approval
Approved	Lee,Yoonkyung	09/04/2017 09:28 PM	Unit Approval
Approved	Haddad,Deborah Moore	09/05/2017 11:04 AM	College Approval
Pending Approval	Nolen,Dawn Vankeerbergen,Bernadette Chantal Oldroyd,Shelby Quinn Hanlin,Deborah Kay Jenkins,Mary Ellen Bigler	09/05/2017 11:04 AM	ASCCAO Approval

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College of Arts and Sciences

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08/25/2017

Professor Yoonkyung Lee
Chair, Curriculum Committee
Department of Statistics
The Ohio State University

Dear Yoon:

As you know, many in the Statistics Department have, for years, felt that we should have an undergraduate major. The department's Undergraduate Major Committee and Curriculum Committee have worked hard over the past year-and-a-half to develop the proposal and to open the proposal to full faculty discussion within the department. The discussions and modifications have produced a proposal that is well thought out and that has the full support of the department.

I believe the case for an undergraduate major in Statistics to be compelling. The world has awakened to the power and insight that comes from combining our understanding of the world (as captured by a model) with data—the essence of Statistics. We regularly receive requests from corporations to put them in touch with our majors for internships and permanent job opportunities. In addition to providing valuable "workforce" training, the major will engage students in one of the fastest moving and most intellectually stimulating parts of the university. This is the right time to move forward with the major.

On behalf of the department (and myself), I am pleased to support the proposal to create an undergraduate major in Statistics.

Sincerely,

Steven MacEachern
Chair and Professor
Department of Statistics

1 Summary

The Department of Statistics currently offers two undergraduate programs: a minor in Statistics, and a major in Data Analytics that is co-administered with the Department of Computer Science and Engineering in the College of Engineering. When it was founded in 1974, the Department offered a major in Statistics, but this major was discontinued in 1994. At that time, very few universities offered undergraduate majors in Statistics, with bachelors degrees in Mathematics providing the necessary preparation for graduate study in Statistics. With the rise of career opportunities related to data analysis and probabilistic modeling within the last 15 years, however, many universities have developed majors in Statistics, and the number of students selecting these majors continues to grow.

During the 2015-16 academic year, a committee of faculty within the Statistics Department convened to examine the feasibility of a new major in Statistics. The committee first examined which other peer universities administered majors in Statistics, comparing this with similar data collected a few years earlier. The committee then began to develop a proposed curriculum, using input from the curricula offered by peer universities, the American Statistical Association (ASA) recommendations for undergraduate degrees, and discussion among the committee members. A preliminary curriculum was presented to the entire faculty in a faculty meeting in April 2016, and feedback from the faculty was incorporated into the proposed curriculum. During the Fall Semester of 2016 and Spring Semester of 2017 this curriculum was further refined by input from the faculty in Statistics. The proposed curriculum consists of core coursework in statistics and mathematics, as well as choices of electives that will allow students to prepare for their expected career path in a focused manner.

2 Rationale

The discipline of Statistics has experienced steady growth in almost every measure over the last 15-20 years. For example, employment of statisticians has grown 54% since 2000, according to the Bureau of Labor Statistics (BLS) Occupational Employment Statistics, with inflation-adjusted mean annual wages for statisticians increasing 12% from 2000 to 2014 [3]. The BLS projection for employment as a statistician in the coming years is equally promising, with an anticipated growth of 34% from 2014-2024, leading to "statistician" ranking 9^{th} in terms of fastest-growing occupations by the U.S. Department of Labor [5].

The rapid increase in demand for trained statisticians has led to the need for increased opportunities for educating professional statisticians. Indeed, the number of universities granting bachelor's degrees in statistics has increased 50% from 2003 to 2013 (see Figure 1; the full list of universities granting degrees in Statistics is available at `http://www.amstat.org/misc/StatsBachelors2003-2013.pdf`) [4], with nearly three times as many bachelor's degrees awarded in 2013 as compared to the number awarded in 2003 (see Figure 2) [1]. The impact can be observed even at the early college level. The College Board, which administers the Advanced Placement exams, has noted that the number of students taking the Advanced Placement test in Statistics has more than tripled since 2001 [2], while enrollment in statistics courses by non-statistics majors increased by 50% from 2005 to 2010, according to the Conference Board of the Mathematical Sciences [5].

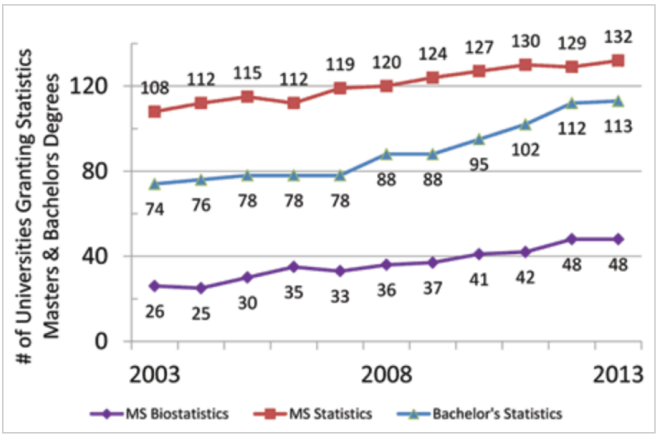

Figure 1: Number of universities granting bachelors degrees in Statistics from 2003 to 2013 (blue line). From [4].

The outlook in Ohio is also optimistic. For example, the current median salary for statisticians in Ohio is $86,470, compared with a national median of $80,110. Yet, bachelors degrees in statistics are only offered at a handful of universities in Ohio: Miami University, University of Akron, Ohio Northern University, Case Western Reserve University, and Wright State University. With the recent addition of a major in Data Analytics at OSU (see Section 4 for more detail concerning the relationship between these two majors) and the increased efforts on campus in the area of data analytics, the Department of Statistics at OSU is uniquely positioned to provide a strong B.S. degree in Statistics to the undergraduate student population from Ohio and beyond.

Students completing a major in Statistics at OSU will be well-positioned for employment in several different careers. First, the major in Statistics will provide solid preparation for further study of statistics at the graduate level, and we note that educational and job opportunities for statisticians trained at the Masters and Ph.D. levels show increases similar to those mentioned

above at the baccalaureate level. Second, students completing the bachelors degree in Statistics at

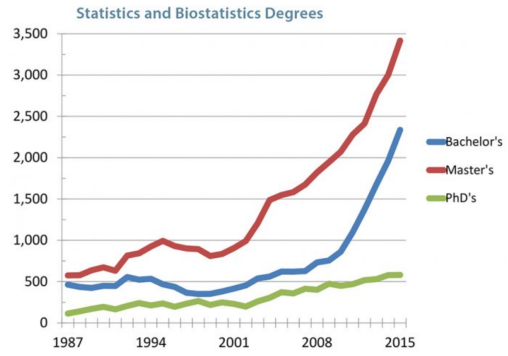

Figure 2: Number of bachelors degrees in statistics awarded from 2003-2015 (red line). From [6].

OSU will be well-prepared for entry-level positions in industry, working in fields such as pharmaceuticals, finance, consumer science, medicine, and environmental science, to name a few. For example, within Columbus, there are numerous opportunities for employment as a statistician, with Nationwide Insurance, Chase, and Battelle regularly hiring OSU-trained statisticians. Finally, statisticians are employed in many entities within the local, state, and federal governments, such as the Census Bureau, the Ohio Departments of Health, Job and Family Services, and Education, and the FDA. For these reasons, the Department of Statistics presents its proposal for an undergraduate major in statistics.

3 Goals/Objectives and Evaluation of Program

This section provides the details of the learning objectives of the major in Statistics leading to the B.S. degree, and describes the process by which the program will be assessed. While assessment data collection will be ongoing, we plan to have the Department of Statistics Undergraduate Curriculum Committee examine the data every 5 years and make a recommendation about whether changes to the program should be considered. We first state the learning objectives, and then give details of our assessment plan.

3.1 Learning Objectives

Students graduating with a B.S. degree with a major in Statistics will have met the following learning objectives.

1. Students will be proficient at exploratory data analysis using graphical and computational tools.

2. Students will understand mathematical concepts relevant to statistical theory, and will be adept at applying these concepts to statistical models for data, such as those arising in the physical, biological, and social sciences, and in business.

3. Students will be able to assess whether hypotheses are supported by data and to quantify uncertainty in parameter estimates and models.

4. Students will be able to develop, fit, assess, and compare statistical models in a formal probabilistic framework.

5. Students will be able to communicate the results of a statistical analysis in both oral and written formats, in a manner appropriate to the audience.

3.2 Program Assessment

Our program assessment will use both direct and indirect methods to determine whether the program is successful in meeting its learning objectives. We begin by noting that each learning outcome has been mapped to a particular set of courses at the begininning (B), intermediate (I), or advanced (A) level (see Section 6). Our first method of direct assessment is the use of embedded exam questions. In particular, learning objectives (1) - (4) will be assessed using embedded questions on the final exam for each course that are targeted at the level of mastery intended (B, I, or A). We will judge the learning objective to be satisfied if at least 70% of the students score above 80% on these embedded exam questions.

Additionally, we will include one method of indirect assessment of our program. We will collect placement data on students within the first 5 years following graduation. We will consider our program successful if at least 80% of the students graduating with the B.S. degree in Statistics have obtained a job or post-baccalaureate placement in Statistics or a related quantitative field within 5 years of graduation. We also plan to collect data about the program from graduating students by using an exit survey. The survey will be administered by the staff as the final step before their graduation.

We will analyze and discuss data collected from our assessments at regular 5 years intervals, so that a sufficient number of data points can accumulate, which will allow trends to be observed. Thus, every 5 years, the Undergraduate Curriculum Committee will discuss all accumulated data, and present a report to the full faculty and to the College of Arts and Sciences. The report will include any recommendations for modification of the program. Although our formal assessment will only be carried out every 5 years, the intermediate data will be examined and used to improve individual courses. Each course instructor will present the data collected on the embedded problems in his/her course to the faculty member overseeing the major, and courses that fall short of meeting the learning objective will be modified in order to improve the areas in which the course is deficient. In addition, we will provide yearly assessment reports to the College of Arts and Sciences for individual courses.

4 Relationship to Other Programs/Benchmarking

The Department of Statistics currently administers a minor in Statistics and co-administers a major in Data Analytics with the Department of Computer Science and Engineering in the College of Engineering. The minor currently has 74 students officially enrolled, though it is typical for students to select this minor late in their academic careers. In the 2015-16 academic year, 29 students graduated with the minor in Statistics. The major in Data Analytics is currently in its fourth year, and has 105 students enrolled, with an additional 138 students enrolled in the pre-major. The first cohort of students graduated with this major in the Spring 2017 commencement. To those unfamiliar with these fields, the distinction between statistics and data analytics may not be clear.

Thus, we begin by briefly describing both fields and how they differ, before providing a discussion of how the proposed major in statistics will differ from the data analytics major.

The field of statistics encompasses the theoretical development and practical application of methods for collecting and analyzing data. It builds upon solid training in mathematical fundamentals to develop models for real processes and to use these models to analyze data. Data analytics is a relatively new term that refers generally to the development of methods for collecting, storing, organizing, and making predictions from large-scale data. The field of data analytics has arisen primarily from recent advances in our ability to collect data that are "large" in some way, for example, data collected on hundreds of thousands of subjects or data collected at high spatial or temporal resolution. Computational issues are at the forefront of methods used in the field of data analytics, and statistical techniques are typically viewed as tools that can assist in learning from large-scale data. Statistics, on the other hand, puts emphasis on the foundations of inferential procedures, while using computational tools to learn about certain aspects of the population, with consideration given to the limitations of the data.

The training required for careers in the fields of statistics and data analytics has important differences. We highlight the differences in training by contrasting the major in Statistics proposed here with the existing major in Data Analytics. First, the Data Analytics major has a much heavier focus on the acquisition of computing skills in order to train students to manage and analyze large-scale data. This can be seen by the number of required credit hours in computing for the Data Analytics major (27 total hours of CSE courses). In contrast, while the major in Statistics does include a computing component, it has a heavier emphasis on foundations of statistical inference. The computing component of the Statistics major is at the level of basic computational proficiency, requiring only 6 total hours in computing: a 3-hour introductory course from the CSE department, and a 3-hour course in Statistical Computing taught by the Statistics Department.

The second distinction between the two majors is in the projected career path of students receiving each degree. The major in Data Analytics prepares students to enter the workforce directly, while the major in Statistics provides the solid theoretical training that is required to enter graduate school following completion of the major. For those students completing the major in Statistics who do not plan to pursue graduate study, however, there are still important differences in the types of careers for which the two majors prepare students. While we hope to educate students broadly so that students graduating with either major can readily adapt to the job requirements in any related field, students graduating with the major in Data Analytics will be most suited for jobs that involve the daily manipulation and analysis of large quantities of data, while students graduating with the major in Statistics will be most suited for jobs requiring standard statistical analyses of data coupled with the ability to provide theoretically-oriented insights. Indeed, the curriculum for the major in Statistics includes several core statistical topics not found in the core of the Data Analytics major, such as experimental design, analysis of observational data, principles of collecting statistical samples, advanced concepts in statistical inference, and computational statistics (with an emphasis on simulation-based inference, rather than storage and manipulation of data). These topics will be covered in newly-offered courses in Principles of Data Collection and Analysis (Stat 3410), Advanced Statistical Inference (Stat 4301), and Computational Statistics (Stat 4302).

Although the two majors differ, they share a fundamental set of tools, and beginning students

will often not appreciate the distinction between the two fields. For these reasons, the proposed major has been designed to be complementary to the major in Data Analytics. We have maintained flexibility between the major in Data Analytics and the major in Statistics, in the sense that four of the courses required by both majors in the sophomore and junior years overlap (Stat 3201, 3202, 3301, 3302). This allows maximum flexibility as students decide which major best fits their career goals and interests.

The other major on campus that is traditionally associated with the field of Statistics is the B.S. degree in Actuarial Science administered by the Department of Mathematics. This major has a current enrollment of 379 students, with 56 students graduating with the major in the Spring 2016 commencement. While students pursuing this major are required to take several courses from the Statistics Department, the projected career path for these students differs from that of both Data Analytics majors and Statistics majors. Students receiving the degree in Actuarial Science are preparing for careers as Actuaries, and devote some of their effort at the undergraduate level to working towards professional licensing as an Actuary by preparing for the Society of Actuaries exams. In contrast, the proposed B.S. degree in Statistics will produce students who are prepared to pursue graduate study in Statistics or to enter the workforce as a practicing statistician in any application area (e.g., business, biological sciences, social sciences, government, etc.).

We anticipate that students selecting the major in Statistics will be drawn from both the current student population and the population of entering freshmen. As mentioned above, current students often select the minor in Statistics after exposure to the field of Statistics via one of the courses required for their major. It is common for students to inquire about the possibility of majoring in Statistics at this time, and it is anticipated that students may add or change their major to Statistics once they become aware of this possibility. Reasonable flexibility in course requirements will be given for students transitioning to the Statistics major from the minor in Statistics and from other majors. In addition, the rise in the number of students taking the AP Exam in Statistics mentioned in Section 2 is an indication of the awareness of the field of Statistics by entering students. The large number of students applying to the Data Analytics major (e.g., 67 students applied during the 2015-16 academic year) indicates that many beginning students are interested in pursuing a statistically-oriented major. Finally, we note that the Department of Statistics participates in the State Science Fair each year by providing several Statistical Analysis Awards. Participation in this event can also be used to recruit students to the major. While we anticipate the major in Statistics being smaller in overall size than the major in Data Analytics, we expect substantial interest in the major from both new and current students, as described below.

5 Student Enrollment

As mentioned above, we anticipate that students will be recruited to the major from both new freshmen entering the university and from existing students. At capacity, we anticipate the major will include approximately 40 students per year. This estimate is based in part on comparison of the number of students completing majors in Statistics at peer institutions with Statistics Departments of size similar to ours (see `http://ww2.amstat.org/misc/StatsBachelors2003-MostRecent.pdf`). For example, the University of Minnesota and University of Michigan graduate approximately 60

students per year majoring in Statistics, North Carolina State University and the University of Wisconsin approximately 40 per year, and Iowa State University approximately 30 per year. Because some of the population who may be selecting the major in Statistics at these universities may select the major in Data Analytics at OSU, we have used the somewhat conservative estimate of 40 students per year. The table below gives enrollment projections over the first 4 years of the major as we gear up to capacity in the major.

Year in Curriculum	Year 1	Year 2	Year 3	Year 4
Freshmen	10	20	30	40
Sophomore	10	15	30	40
Junior	5	15	20	35
Senior		5	15	20
Total Enrollment	25	55	95	135

With the addition of the major, the Statistics Department will have the need for increased faculty and administrative support. We ask that a portion of the duties of the approved but not yet filled Teaching Specialist position be allocated to administrative tasks associated with the major (e.g., monitoring student progress and serving as a contact point for ASC Advisors, etc.). Our proposal also includes the development of four new courses:

- Stat 1550: Introduction to Statistical Reasoning (3 hours)
- Stat 3410: Principles of Data Collection and Analysis (3 hours)
- Stat 4301: Advanced Statistical Inference (3 hours)
- Stat 4302: Computational Statistics (3 hours)

We note that two of the courses, Stat 1550 and Stat 4302 (computing), are anticipated to have enrollment from students outside of the Statistics major in addition to those within the major. We anticipate that the Department of Statistics would need two new faculty to assist in the development and instruction of these new courses.

The courses required in the major will also impact existing courses in the department. At capacity, the major will enroll 40 additional students per year in the courses Stat 3201, Stat 3202, Stat 3301, and Stat 3302, necessitating one new section of each of these courses per year. In the first few years of the major, the existing sections of these courses can likely accommodate the smaller number of students. New sections of Stat 3201 and Stat 3202 would thus be needed by year 3 of the proposed major, and new sections of Stat 3301 and Stat 3302 would be needed by year 4 of the proposed major. We anticipate that the Department of Statistics would need two new faculty to carry out instruction in these new sections. In total, **the Department of Statistics would need an additional four faculty members, hired over the next four years, to administer the major.**

6 Curricular Requirements

B.S. Degree – Statistics Major **The Ohio State University**
Proposed Program Requirements College of Arts and Sciences

The program requirements for the Bachelor of Science degree with a major in **Statistics** are given below. A minimum of 115 credit hours is required by the major; 121 hours are required for graduation.

1. Statistics Major Core Requirements

Course Number	Course Title	Credit Hours	Credit Hours Counted Toward Major
Math 1151[a]	Calculus I	5	0
Math 1152[a]	Calculus II	5	0
Math 2153	Calculus III	4	4
Math 2568	Linear Algebra	3	3
Choice of			
(1) Math 3345	Foundations of Higher Mathematics	3	3
Math 4547	Introductory Analysis I	3	3
OR			
(2) 6 hours in	Mathematics at the 2000-level or higher[c]	6	6
CSE 1221,	Intro to Computer Programming		
1222, or 1223	in { Matlab, C++, Java }	3	3
Stat 1550[b]	Introduction to Statistical Reasoning	3	0
Stat 3201	Intro Prob Data Analytics	3	3
Stat 3202	Intro Stat Inf Data Analytics	4	4
Stat 3301	Stat Modeling for Discovery I	3	3
Stat 3302	Stat Modeling for Discovery II	3	3
Stat 3410	Principles of Data Collection and Analysis	3	3
Stat 4301	Advanced Statistical Inference	3	3
Stat 4302	Computational Statistics	3	3
Total		51	38

[a] Math 1151 and Math 1152 are used in the Statistics Major Curriculum to fulfill General Education Requirements and so their credit hours do not count toward the major. [b] This course may be replaced by Statistics 1000–2000 level GE data analysis courses (1350, 1430, 1430H, 1450, 2450, and 2480) or an upper-level elective if a student enters the program after their first year. [c] Approved courses include Math 2255, 2415, 3345, 3350, 3532, 3607, 4350, 4507, 4547, 4548, 4556, 4557, 4575, and 4578.

2. Statistics Major Electives

Students must complete an additional 15 hours of electives. This must include 9 hours in Statistics at the 3000-level or higher (Category I: selected from the courses: Stat 3303, 4620, 5510, 5550, 5740) and 6 hours in Statistics or Mathematics at the 3000-level or higher (Category II: selected from the previous list of Statistics courses and the following Mathematics courses: Math 2255, 2415, 3345, 3350, 3532, 3607, 4350, 4507, 4547, 4548, 4556, 4557, 4575, 4578). Students wishing to pursue graduate work in Statistics may wish to take 6 of these hours from the Mathematics Department in order to prepare for more theoretically-oriented graduate work. In particular, the sequence Math 3345, Math 4547, and Math 4548 is recommended for students planning to attend graduate school.

3. General Education Requirements

Students must satisfy the General Education requirements for the Bachelor of Science degree in the College of Arts and Sciences. Note that Math 1151 and Math 1152 are required for the major core curriculum. It is suggested that students use these courses to satisfy the categories shown in the table below. Stat 1550 is suggested to satisfy Data Analysis requirement, as shown below.

GE Category	Suggested or Required Course	Minimum Course Credit Hours	Minimum Category Credit Hours
Writing			6
Literature			3
Arts			3
Mathematics	Math 1151	5	5
Data Analysis	Stat 1550		3
Natural Science			10
Historical Study			3
Social Science			6
Culture and Ideas or Historical Study			3
Language			12
Open Option 1	Math 1152	5	5
Open Option 2		3	3
Total			62

4. Program Outcomes

The **Learning Objectives** for the major in Statistics are given below, followed by a map between courses and the level at which the course meets the objective.

Students graduating with a B.S. degree with a major in Statistics will have met the following learning objectives:

1. Students will be proficient at exploratory data analysis using graphical and computational tools.
2. Students will understand mathematical concepts relevant to statistical theory, and will be adept at applying these concepts to statistical models for data, such as those arising in the physical, biological, and social sciences, and in business.
3. Students will be able to assess whether hypotheses are supported by data and to quantify uncertainty in parameter estimates and models.
4. Students will be able to develop, fit, assess and compare statistical models in a formal probabilistic framework.
5. Students will be able to communicate the results of a statistical analysis in both oral and written formats, in a manner appropriate to the audience.

Program outcomes[a]**:** *(B=beginner, I=intermediate, A=advanced)*

Course	Learning Objective 1	Learning Objective 2	Learning Objective 3	Learning Objective 4	Learning Objective 5
Required Courses (offered by the unit)					
Stat 1550	B	B	B	B	B
Stat 3201		A			
Stat 3202		A	I	B	I
Stat 3301	I		A	I	A
Stat 3302	I		A	I	A
Stat 3410	I		A	I	A
Stat 4301		A	A	A	
Stat 4302	A		I	A	I
Required Courses (offered outside of the unit)					
Math 1151		B			
Math 1152		B			
Math 2153		B			
Math 2568		I			
CSE 122x	B				
Elective Courses (offered by the unit)					
Stat 3303	I	I	A	A	A
Stat 4620	I	I	A	A	A
Stat 5510		I	A	I	A
Stat 5550	I	I	A	A	A
Stat 5740	I		B	I	I

[a]
1. Students will be proficient at exploratory data analysis using graphical and computational tools.
2. Students will understand mathematical concepts relevant to statistical theory, and will be adept at applying these concepts to statistical models for data, such as those arising in the physical, biological, and social sciences, and in business.
3. Students will be able to assess whether hypotheses are supported by data and to quantify uncertainty in parameter estimates and models.
4. Students will be able to develop, fit, assess and compare statistical models in a formal probabilistic framework.
5. Students will be able to communicate the results of a statistical analysis in both oral and written formats, in a manner appropriate to the audience.

Program outcomes[a]**:** *(B=beginner, I=intermediate, A=advanced)*

Course	Learning Objective 1	Learning Objective 2	Learning Objective 3	Learning Objective 4	Learning Objective 5
Elective Courses (offered outside of the unit)					
Math 2255		I			
Math 2415		I			
Math 3345		I			
Math 3350		I			
Math 3532		I			
Math 3607		I			
Math 4350		A			
Math 4507		A			
Math 4547		A			
Math 4548		A			
Math 4556		A			
Math 4557		A			
Math 4575		A			
Math 4578		A			
GE Courses	B				

[a]
1. Students will be proficient at exploratory data analysis using graphical and computational tools.
2. Students will understand mathematical concepts relevant to statistical theory, and will be adept at applying these concepts to statistical models for data, such as those arising in the physical, biological, and social sciences, and in business.
3. Students will be able to assess whether hypotheses are supported by data and to quantify uncertainty in parameter estimates and models.
4. Students will be able to develop, fit, assess and compare statistical models in a formal probabilistic framework.
5. Students will be able to communicate the results of a statistical analysis in both oral and written formats, in a manner appropriate to the audience.

5. Sample Four-Year Curriculum

Year	Autumn		Spring	
	Course	**Hours**	**Course**	**Hours**
1	ASC 1110	1	Stat 1550: Stat Reasoning	3
	Math 1151: Calc I	5	Math 1152: Calc II	5
	GE Writing Level 1	3	GE Open Option	3
	GE Foreign Language I	4	GE Foreign Language 2	4
		Total: 13		Total: 15
2	Math 2153: Calc III	4	Math 2568: Linear Algebra	3
	Stat 3201: Intr Prob for DA	3	Stat 3202: Intr Stat Inf DA	4
	GE Physical Science (lab)	4	GE Writing Level 2	3
	GE Foreign Language 3	4	CSE 122(1,2,3): Matlab, C++, Java	3
		Total: 15		Total: 13
3	Stat 3301: Stat Model Disc 1	3	Stat 3302: Stat Model Disc 2	3
	Stat 3410: Prin Data Collect	3	Stat elective[b]	3
	Math 3345: Found Higher Math[a]	3	Math 4547: Intro Anal I[a]	3
	GE Social Sciences	3	GE Biological Sciences (lab)	4
	GE Natural Science	3	GE Social Sciences	3
		Total: 15		Total: 16
4	Stat 4301: Adv Stat Inf	3	Stat 4302: Comp Stat	3
	Stat elective[b]	3	Stat elective[b]	3
	Stat/Math Elective[c]	3	Stat/Math Elective[c]	3
	GE Historical Study	3	GE Cultural & Ideas or Hist. Study	3
	GE Arts	3	GE Literature	3
		Total: 15		Total: 15

[a] The sequence Math 3345 - Math 4547 is one option; this can be replaced with two Math courses at the 2000-level or higher selected from a list of approved electives (see page 8).

[b] Category I Stat Elective: Choice of any of the following Stat classes: Stat 3303, 4620, 5510, 5550, 5740.

[c] Category II Stat/Math Elective: Choice of any of the following Stat or Math classes: Stat 3303, 4620, 5510, 5550, 5740; Math 2255, 2415, 3345, 3350, 3532, 3607, 4350, 4507, 4547, 4548, 4556, 4557, 4575, 4578.

References

[1] American Statistical Association Undergraduate Guidelines Working Group (2014). Curriculum Guidelines for Undergraduate Programs in Statistical Science, available at http://www.amstat.org/education/curriculumguidelines.cfm.

[2] Bialik, C. (2013) Data Crunchers Now the Cool Kids on Campus, The Wall Street Journal, March 2, 2013.

[3] Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, 2016-17 Edition, Statisticians, on the Internet at http://www.bls.gov/ooh/math/statisticians.htm (visited August 15, 2016).

[4] Pierson, S. (2014) Bachelor's Degrees in Statistics Surge Another 20%, *Amstat News*, September 1, 2014; available at http://magazine.amstat.org/blog/2014/09/01/degrees/.

[5] Pierson, S. (2016). Statistician Projected as Top-10 Fastest Growing Job, American Statistical Association Press Release, January 18, 2016, available at http://www.eurekalert.org/pub_releases/2016-01/asa-spa011516.php.

[6] Pierson, S. (2016) Statistics, Biostatistics Degree Growth Sustained Through 2015, Amstat News, available online at http://magazine.amstat.org/blog/2016/10/01/science-policy/?utm_source=anoct16&utm_medium=email&utm_campaign=amstatnews

STATISTICS
PROPOSED BACHELOR OF SCIENCE MAJOR

The proposed major in ***Statistics*** consists of a required foundational core of 12 courses. An additional 15 hours of electives are met by students choosing 9 hours from Category I Electives and 6 hours from Category II Electives. Math 1151 and 1152 satisfy general education requirements, *Quant & Logical Skills* and *Open Option #1*. Stat 1550 satisfies general education requirement, *Data Analysis*. (See sample program.) Stat 1550, 3410, 4301 and 4302 are four new courses proposed concurrently with the major.

	COURSE (Credit Hours)	DESCRIPTION	PREREQUISITES
STATISTICS, BS **REQUIRED CORE** **12 COURSES** **38 HOURS**	**MATH 2153:** *Calculus III (4)*	Multivariable differential & integral calculus.	A grade of C- or above in 1152, 1172, 1534, 1544, 1181H, or 4181H.
	MATH 2568: *Linear Algebra (3)*	Matrix algebra, vector spaces & linear maps, bases & dimension, eigenvalues & eigenvectors, applications.	A grade of C- or above in 1172, 1544, 2153, 2162.xx, 2182H, or 4182H; or a grade of C- or above in both 1152 & CSE 2321.
	2 Additional MATH Courses: *Choose 2 courses as indicated in the* **DESCRIPTION** *column to the right.*	1. **MATH 3345:** *Foundations of Higher Mathematics (3)* **-- AND --** 2. **MATH 4547:** *Introductory Analysis I (3)* **-- OR –** 1. **6 Credit Hours:** Approved MATH courses at 2000-level or higher (6)[1]	1. **MATH 3345:** Major or minor in Math, CSE, CIS, ECE. 2. **MATH 4547: C- or better in 3345.** 1. Various prerequisites.
	CSE 1221 *(2)*, ***OR*** **1222** *(3)*, ***OR*** **1223** *(3)*: *Intro to Computer Programming in {MATLAB; C++; Java} (3)*	**CSE 1221:** Introduction to computer programming & problem solving techniques with applications in engineering & the physical sciences; algorithm development; programming lab experience.	**CSE 1221:** Engr 1181, 1281. This course is available for EM credit.
		CSE 1222: *Introduction to computer programming & to problem solving techniques using computer programs with applications in engineering & the physical sciences; algorithm development; programming lab experience.*	**CSE 1222:** Math 1151 or 1161. This course is available for EM credit.
		CSE 1223: Introduction to computer programming & to problem solving techniques using computer programs; programming lab experience.	**CSE 1223:** This course is available for EM credit.

[1] Approved courses include Math 2255, 2415, 3345, 3350, 3532, 3607, 4350, 4507, 4547, 4548, 4556, 4557, 4575, and 4578.

	COURSE (Credit Hours)	DESCRIPTION	PREREQUISITES
	STAT 1550: *Intro to Statistical Reasoning (3)*	Introduction to statistical reasoning through data and application examples, including an introduction to coding in the R software; intended for students considering the Statistics major.	(or Coreq) Math 1152; or permission of instructor.
	STAT 3201: *Intro to Probability for Data Analytics (3)*	An introduction to probability & its role in statistical methods for data analytics. Equal emphasis is placed on analytical & simulation-based methods for quantifying uncertainty. Approaches to assessing the accuracy of simulation methods are discussed. Applications of probability & sampling to big-data settings are discussed.	Math 1152, 1161.xx, 1172, 1181, or equiv; or permission of instructor.
	STAT 3202: *Intro* Statistical *Inference for Data Analytics (4)*	Foundational inferential methods for learning about populations from samples, including point & interval estimation, & the formulation & testing of hypotheses. Statistical theory is introduced to justify the approaches. The course emphasizes challenges that arise when applying classical ideas to big data, partially through the use of computational & simulation techniques.	C- or better in 3201, or permission of instructor.
	STAT 3301: *Statistical Modeling for Discovery I (3)*	Statistical models for data analysis & discovery in big-data settings, with primary focus on linear regression models. The challenges of building meaningful models from vast data are explored, & emphasis is placed on model building & the use of numerical & graphical diagnostics for assessing model fit. Interpretation & communication of the results of analyses is emphasized.	C- or better in 3202; or permission of instructor. Prereq or concur: Math 2568; or permission of instructor.
	STAT 3302: *Statistical Modeling for Discovery II (3)*	Statistical models for data analysis & discovery in big-data settings. The regression methods developed in Stat 3301 are extended to data settings with binary & multi-category outcomes. An introduction to some of the most commonly used statistical methods for exploring & analyzing multivariate data is provided. Interpretation & communication of the results of analyses is emphasized.	C- or better in 3301, & Math 2568; or permission of instructor.
	STAT 3410: *Principles of Data Collection & Analysis (3)*	Principles of designing experiments; analysis of variance techniques for hypothesis testing; simultaneous confidence intervals; block designs; factorial experiments; random effects and mixed models; observational data	3201 & 3202; or permission of instructor.
	STAT 4301: *Advanced Statistical Inference (3)*	Advanced probability models and fundamentals of inferential procedures; distribution functions, moment generating functions, transformations, order statistics, large-sample theory, classical hypothesis testing, distribution-free hypothesis tests.	3201 & 3202; or Stat 4201 & 4202; or permission of instructor.
	STAT 4302: *Computational Statistics (3)*	Topics in computational statistics using the R software, including design and execution of classical and modern Monte Carlo experiments, and statistical inference based on resampling methods, such as bootstrap, jackknife, and permutation.	4301; or permission of instructor.

	Course (Credit Hours)	Description	Prerequisites
Category I Electives **9 Hours in STAT at 3000-Level or Higher**	**STAT 3303:** *Bayesian Analysis & Statistical Decision Making (3)*	Introduction to concepts & methods for making decisions in the presence of uncertainty. Topics include: formulation of decision problems & quantification of their components; learning about unknown features of a decision problem based on data via Bayesian analysis; characterizing & finding optimal decisions. Techniques & computational methods for practical implementation are presented.	C- or better in 3202, or permission of instructor.
	STAT 4620: *Introduction to Statistical Learning (2)*	The course provides an introduction to the principles of statistical learning & standard learning techniques for regression, classification, clustering, dimensionality reduction, & feature extraction.	C- or better in 3302, or permission of instructor.
	STAT 5510: *Statistical Foundations of Survey Research (3)*	Understand & practice methods of survey research & data analysis including questionnaire design & pilot testing, non-sampling & sampling errors, sampling design, descriptive statistics, estimation, & hypothesis testing; & ethics.	1350, 1450, or 5301, & Math 1075, or equiv; or permission of instructor. Not open to students with credit for 6510.
	STAT 5550: *Introductory Time Series Analysis (3)*	Introduces the statistical methodology & models to analyze time series data in practice.	3301; or 4202 & 5302, or permission of instructor. Not open to students with credit for 6550 or 7550.
	STAT 5740: *Introduction to SAS Software (2)*	The basic statistical procedures covered will be illustrated using SAS. The intent of the course is to cover some of the SAS statistical methods that graduate students from outside the Statistics Department require for their own research.	5302 or permission of instructor.

	Course	Description	Prerequisites
	STAT Category II Electives: *Choose from Category I Electives not already chosen for Category I credit toward the major.*	*See Category I Electives above.*	*See Category I Electives above.*

	COURSE	DESCRIPTION	PREREQUISITES
CATEGORY II ELECTIVES[2] **6 HOURS IN STAT OR MATH AT 3000-LEVEL OR HIGHER**	**MATH 2255:** *Differential Equations & Their Applications (3).*	Ordinary differential equations, their series solutions, numerical methods, Laplace transforms, physical applications.	A grade of C- or above in 2153, 2162.xx, 2173, 2182H, or 4182H
	MATH 2415: *Ordinary & Partial Differential Equations (3)*	Ordinary & partial differential equations: Fourier series, boundary & initial value problems.	2153, 2162.xx, 2173, 2182H, 4182H, 254.xx, or 2568 & either 1172 or 1544.
	MATH 3345: *Foundations of Higher Mathematics (3)*	Introduction to logic, proof techniques, set theory, number theory, real numbers.	Major or minor in Math, CSE, CIS, ECE.
	MATH 3350: *Introduction to Mathematical Biology (3)*	Introduction to quantitative & qualitative analysis of several mathematical models for biological systems.	C- or better in Math 2255, 2415, 5520H.
	MATH 3532: *Mathematical Foundations of Actuarial Science (3)*	Problem workshop for applications of calculus & probability to actuarial science & risk management.	C- or better in 4530, 5530H, or Stat 4201.
	MATH 3607: *Beginning Scientific Computing (3)*	Introduction to mathematical theory of algorithms used to solve problems that typically arise in sciences, engineering, & finance.	C- or better in 2255 or 2415, & C- or better in 2568 or 5520H.
	MATH 4350: *Quantitative Neuroscience (3)*	Introduction to mathematical modeling & computational analysis of neuronal systems, Hodgkin-Huxley model, dynamical systems methods, neuronal networks, models for neurological disease.	1152 or 1157 or permission of instructor.
	MATH 4507: *Geometry (3)*	Topics in Euclidean, spherical, & hyperbolic geometries.	C- or above in 3345, & in 2568 or 5520H.
	MATH 4547: *Introductory Analysis I (3)*	4547 - 4548 involves advanced calculus: sequences, limits, continuity, differentiation, Riemann integral, sequences & series of functions, Taylor series, & improper integrals.	C- or better in 3345.
	MATH 4548: *Introductory Analysis II (3)*	Continuation of Math 4547. Advanced calculus: sequences, limits, continuity, differentiation, Riemann integral, sequences & series of functions, Taylor series, & improper integrals.	C- or better in 4547.
	MATH 4556: *Dynamical Systems (3)*	Systems of linear, first-order differential equations; existence & uniqueness theorems; numerical methods; qualitative theory; & physical applications.	C- or above in 2153, 2162.xx, 2173, 2182H, or 4182H.

[2] Students wishing to pursue graduate work in Statistics may wish to take 6 of these hours from the Mathematics Department in order to prepare for more theoretically-oriented graduate work. In particular, the sequence Math 3345, Math 4547, & Math 4548 is recommended for students planning to attend graduate school.

	COURSE	DESCRIPTION	PREREQUISITES
	MATH 4557: *Partial Differential Equations (3)*	First & second-order PDE's; existence & uniqueness, initial & boundary value problems, Fourier series; Green's functions; wave, heat & Laplace equations; nonlinear PDE's; applications.	C- or better in 2255, 2415, 4556, or 5520H; or credit for 415.xx. Intended for Math majors. Not open to students with credit for 4512.
	MATH 4575: *Combinatorial Mathematics (3)*	Classic puzzles of recreational mathematics; matching theory & graph theory; enumeration techniques; combinatorial analysis**.**	C- or better in 2568 or 5520H; not open to students with credit for 5529H.
	MATH 4578: *Discrete Mathematical Models (4)*	Homogeneous & non-homogeneous difference equations of one or several variables, Markov chains, graph theory, network flows.	C- or better in 2568 or 5520H; & also a C- or better in 4530, 5530H or Stat 4201.

BACHELOR OF SCIENCE -- STATISTICS
Core …… 38 hours Category I Electives ……..…… 9 hours Category II Electives ……..…….. 6 hours Minimum Hours Required ……..… 53 hours

FW: Statistics Major - concurrence request

Lee, Yoonkyung
Sent: Wednesday, August 23, 2017 4:24 PM
To: Lee, Yoonkyung

From: Carlson, Timothy
Sent: Friday, August 04, 2017 9:56 AM
To: MacEachern, Steven
Cc: Casian, Luis; Husen, William
Subject: Fwd: Statistics Major - concurrence request

Professor MacEachern,

Luis Casian, Bill Husen and I have discussed your proposal for an undergraduate Statistics major and are happy to grant concurrence. We look forward to hearing more about the program as it develops.

Best,
Tim Carlson
Vice Chair for Undergraduate Studies
Department of Mathematics

> Begin forwarded message:
>
> **From:** "Casian, Luis" <casian@math.ohio-state.edu>
> **Subject: Fwd: Statistics Major - concurrence request**
> **Date:** July 31, 2017 at 2:05:45 PM EDT
> **To:** "Carlson, Timothy" <carlson@math.ohio-state.edu>, "Husen, William" <husen@math.ohio-state.edu>
>
> Can you take a look at this request for concurrence?
>
> > Begin forwarded message:
> >
> > **From:** "MacEachern, Steven" <snm@stat.osu.edu>
> > **Subject: Statistics Major - concurrence request**
> > **Date:** July 23, 2017 at 11:11:44 AM EDT
> > **To:** "Casian, Luis" <casian@math.ohio-state.edu>
> > **Cc:** "MacEachern, Steven" <snm@stat.osu.edu>
> >
> > Hi Luis.
> >
> > Our faculty have been working on plans for an undergraduate Statistics major, something we do not currently have. We believe the major will nicely complement the undergraduate major in Data Analytics.

> The attached pdf contains the current proposal. At the moment, we are seeking concurrence from departments impacted by the proposed major.
>
> As part of the new Statistics major, we wish all to have a basic foundation in Mathematics and to have basic programming skills. The former skills are, of course, best taught by your department, and we hope to require calculus (three semesters) and linear algebra (one semester) from your slate of courses (page 8 of the proposal). Number of majors is speculative at this point, as is their provenance. Personally, I suspect that many potential majors will be double majors who would currently take at least a year of calculus as part of their other major. Our hope is to get the major on the books and then grow and tweak it as we better understand the undergraduate audience here at Ohio State.
>
> Would it be possible for you to provide a letter of concurrence for the major?
>
> My best,
>
> Steve

RE: CSE concurrence

Wenger, Rephael
Sent: Friday, August 25, 2017 11:49 AM
To: MacEachern, Steven
Cc: Lee, Yoonkyung; Sivilotti, Paul; Zhang, Xiaodong; Soundarajan, Neelam

Steve,

Sorry we didn't answer this sooner. The last two weeks in August are the most hectic in the year.

CSE is fine with the proposed undergraduate statistics major. Requiring CSE 1222 (C++) or CSE 1223 (Java) is also fine. Those courses are open to all OSU students and CSE 1222 is required by many majors.

EED (Engineering Education) currently teaches CSE 1221 (Intro to Computer Programming in MATLAB for Engineers and Scientists) so I can't speak for that course.

If you decide to require 2000 or higher CSE courses, you will need the concurrence of our curriculum committee and we will need some estimates on numbers. We do have other majors which require some of our courses, but our courses are in very heavy demand, so we do like to keep control on those requirements.

- Rafe Wenger
CSE Associate Chair

Rephael Wenger, CSE Associate Chair and Associate Professor
The Ohio State U., Dept. of Comp. Sci. and Eng.
485 Dreese Lab, 2015 Neil Ave, Columbus, Ohio 43210-1277
Tel: (614) 292-6253. E-mail: wenger.4@osu.edu

From: Zhang, Xiaodong
Sent: Thursday, August 24, 2017 10:06 PM
To: MacEachern, Steven; Sivilotti, Paul; Wenger, Rephael
Cc: Lee, Yoonkyung
Subject: RE: CSE concurrence

Hello, Steve,

Sorry to reply you late. We will respond to you as soon as possible.

Xiaodong

From: MacEachern, Steven
Sent: Tuesday, August 22, 2017 6:48 PM
To: Sivilotti, Paul; Wenger, Rephael; Zhang, Xiaodong

Cc: Lee, Yoonkyung
Subject: RE: CSE concurrence

Hi all.

I thought to send a gentle reminder that we hope for a letter of concurrence for the proposed undergraduate Statistics major. Our goal is to hit an end-of-August deadline in our college to move the major along as quickly as possible.

If you have any concerns about the proposed major, I would be pleased to meet with you to chat about them.

My best,

Steve

From: MacEachern, Steven
Sent: Tuesday, August 15, 2017 12:37 PM
To: Sivilotti, Paul; Wenger, Rephael
Cc: MacEachern, Steven; Lee, Yoonkyung
Subject: FW: CSE concurrence

Hi Paul and Rephael.

I had sent this to Xiaodong, but it occurred to me that the two of you may be more appropriate recipients. Our hope is to have an indication of concurrence from CSE so that we can proceed with paperwork on the newly proposed major.

My best,

Steve MacEachern
Chair, Department of Statistics

From: MacEachern, Steven
Sent: Sunday, July 23, 2017 11:08 AM
To: Zhang, Yinqian
Cc: MacEachern, Steven
Subject: CSE concurrence

Hi Xiaodong.

Our faculty have been working on plans for an undergraduate Statistics major, something we do not currently have. We believe the major will nicely complement the undergraduate major in Data Analytics. The attached pdf contains the current proposal. At the moment, we are seeking concurrence from departments impacted by the

proposed major.

As part of the new Statistics major, we wish all to have a basic foundation in Mathematics and to have basic programming skills. The latter skills are, of course, best taught by your department, and we hope to require one of your programming courses--CSE 1221, 1222, or 1223. Number of majors is speculative at this point, as is their provenance. Personally, I suspect that many potential majors will be double majors who would currently take the CSE course as part of their other major. Our hope is to get the major on the books and then grow it as we better understand the undergraduate audience here at Ohio State.

Would it be possible for you to provide a letter of concurrence for the major?

My best,

Steve