PROGRAMMATIC ASSESSMENT FOR AN UNDERGRADUATE STATISTICS MAJOR

by

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(Under the Direction of Jennifer Kaplan)

ABSTRACT

Programmatic assessment is used by institutions and/or departments to prompt conversations about the status of student learning and make informed decisions about educational programs. This report follows the experiences of the Department of Statistics at the University of Georgia during their process of developing an assessment plan for the undergraduate statistics major. The cyclic assessment process includes four steps: establishing student learning outcomes, deciding on assessment methods, collecting and analyzing data, and reflecting on the results. The theory behind each of these steps and the concept of curriculum mapping is discussed. Key assessment terms, like direct and indirect measures, are introduced in relation to popular assessment methods. Rubrics are also advocated as a direct method that aids in program assessment. The report concludes with a recommendation for an assessment plan for the department.

INDEX WORDS: Student learning outcomes; Programmatic assessment; Curriculum mapping; Undergraduate statistics; Assessment methods

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CHAPTER 1

INTRODUCTION

Programmatic assessment is the process of collecting data to make informed decisions and changes to education programs (Peck & Chance, 2007). This is different from typical classroom assessment used by instructors on a regular basis to measure student knowledge in a particular course. While program assessment is often done because it is required by accreditation agencies, it also provides useful insight into the program as a whole (Hatfield, 2009). The process prompts conversations about the overall status of student learning and the strengths and weakness of students (Jonson, 2006; Stassen et al., 2001). It can also be used to determine whether students can synthesize ideas learned in individual courses to solve more complex problems (Palomba & Banta, 1999). Programmatic assessment also helps faculty to design their courses and focus instruction on key learning outcomes (Jonson, 2006; Stassen et al., 2001).

Program assessment has become a requirement for all university level academic departments under accreditation such as that provided by the Southern Association of College and Schools (SACS). Program assessment is especially important for statistics departments because of the relatively rapid increase in enrollment at the undergraduate level. The industry has also seen increased demand for people trained in statistics due in part to the availability of large data sets, or big data, and the need for analysts of such data. These changes are forcing departments to adapt the undergraduate programs to meet industry and university demands. Currently, "there is a wide disparity in the curriculum at various institutions and confusion on the part of employers as to the skills and abilities that can be expected of a bachelor's level statistician" (Bryce, Gould, Notz, & Peck, 2000, p. 6). Program assessment can help to reconcile these expectations and curriculum realities within the department. Ritter, Starbuck, and Hogg (2001) call the Bachelor of Science degree in statistics "widely under-valued" with the "potential for greater visibility and contribution" (p. 7). By analyzing student learning through program assessment, departments can determine ways to improve their program and increase the value of their graduates in the workforce.

This report will help not only statistics departments, but all departments interested in program assessment. While most places have an existing assessment plan, all departments can benefit from revaluating their existing documents and procedures (Hatfield, 2009). By going through the assessment process documented in subsequent chapters, faculty can learn a great deal about their programs. Through the discussion of student learning outcomes, faculty can determine the expectations they have for their graduates. The process can also uncover what the collective group of faculty members value most in their program. Programs that use a curriculum map to match their desired outcomes to courses can learn whether or not their outcomes are achievable within current program requirements. Their courses should form a logical whole and allow a progression of learning through the curriculum. Departments using this report as a guide will be introduced to a variety of assessment methods and types that can be chosen. While there are many options for assessment methods, it is suggested that programs choose methods based on their ability to gather valuable information and feasibility given department resources. Programs are reminded of the importance of "closing the loop" of assessment by synthesizing data collected to make changes to a program.

The literature review in Chapter 2 discusses the benefits and steps in the programmatic assessment cycle. It also explains the theory behind student learning outcomes, curriculum mapping, and assessment plan design. Chapter 2 ends with a discussion of student learning outcomes in statistics and assessment in similar statistics programs. Chapter 3 describes the local situation of the Department of Statistics at the University of Georgia (UGA). It includes the UGA assessment process, information on the department, and previous assessment procedures. Chapter 4 follows the department's current process of redeveloping student learning outcomes and selecting assessment methods. Finally, Chapter 5 concludes with the future directions for the statistics department at UGA. An ideal assessment plan is presented as a recommendation to maximize the data gathered on student learning across the undergraduate program.

CHAPTER 2

LITERATURE REVIEW

2.1 Purpose of Programmatic Assessment

In general, the term assessment means any process of gathering and analyzing information on topics, courses, institutions, or departments (Stassen, Doherty, & Poe, 2001; Upcraft & Schuh, 2001). Faculty members are accustomed to thinking about classroom assessments, like homework, projects, or exams, within their individual courses, but the process of programmatic assessment is not typically understood by faculty members who are asked to conduct it (Peck & Chance, 2007). While classroom assessments have their place within program assessment, the two types of assessment differ with respect to their overall purposes. Classroom assessments seek to evaluate students, courses, or even professors, but fail to provide insight into the overall student learning experience. Programmatic assessment is used to determine whether students can to combine ideas learned in individual courses into a coherent whole (Palomba & Banta, 1999). The overall purpose of program assessment is to prompt conversations about the status of student learning. Palomba and Banta (1999) describe programmatic assessment as "the systematic collection, review, and use of information about educational programs undertaken for the purpose of improving student learning and development" (p. 4). They state that assessment is more than just collecting data; it involves using the data to make informed decisions about and changes to educational programs. Peck and Chance (2007) describe program assessment as the systematic process that:

> Allows a department to articulate what they value in terms of student learning and to consider the match between what is valued and what the program as taught actually delivers. It is through this reconciliation of discrepancies revealed that programs evolve and student learning improves. (p. 2)

In addition to understanding student learning, there are several potential benefits of conducting programmatic assessment. First, it helps faculty members to design their courses and focus instruction on the core competencies that are expected of students. Faculty members are able to see where their course fits into the curriculum and discuss its impact on student learning. Programmatic assessment, therefore, opens a crucial dialogue between educators regarding possible improvements to their educational programs. The results of program assessment also provide reliable data regarding the strengths and weaknesses of graduating students. The data collected during programmatic assessment gives direction to faculty members on ways to enhance the academic preparation students receive through the program. This allows faculty members to improve their teaching methods and course procedures without having to rely as heavily on student evaluations (Jonson, 2006; Stassen et al., 2001).

The process of programmatic assessment has four essential steps: establishing student learning outcomes, deciding on assessment methods, collecting and analyzing the data, and reflecting on the results. Figure 1 represents the cyclic process of assessing student learning as described by Gordon (2013b), the UGA Office of Academic Planning (OAP) (n.d.), and Peck & Chance (2007). The cycle begins with the establishment of the student learning outcomes in step 1. Step 2 includes the development of an assessment plan. In this step, programs should determine where students can demonstrate effectively the learning outcomes. It is important that learning outcomes and assessment methods are reasonably linked to maximize the information gathered through the process (Hatfield, 2009). The third step is the act of collecting and analyzing data from the program assessment methods. The final step is reserved for reflecting and discussing the results (Peck & Chance, 2007). The most important process occurs in step 4, where "closing the loop" takes place (OAP, n.d.). In this step, faculty use the results obtained from assessment to implement changes within their departments, adapt curricula, and edit previous learning outcomes.

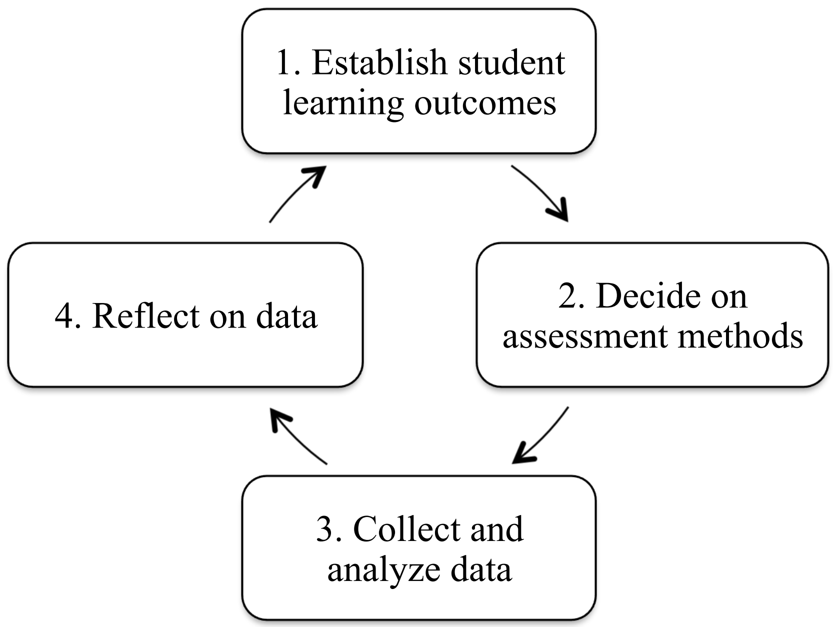

Figure 1. Assessment Cycle

2.2 Theory of Student Learning Outcomes

Student learning outcomes (SLOs) are defined by Suskie (2009) as "the knowledge, skills, abilities, and habits of mind that students take with them from a learning experience" (p. 117). A clarification between program and course student learning outcomes is provided by the UGA Office of Academic Planning (n.d.). Program outcomes are broad descriptions of the knowledge, skills, and abilities of students who graduate from the department (Hatfield, 2009). These outcomes represent the entire progression of courses that are required for the degree. On the other hand, course outcomes are specific to a class. Often included on the course syllabus, they describe what will be taught and tested during that semester. Course outcomes are typically better understood by instructors and commonly assessed through in-class activities. In other literature, the distinction is made between broader program goals and the more focused outcomes (Lindholm, 2009; Stassen et al., 2001; and Suskie, 2009). Gordon (2013a) suggests that departments agree on 4-6 programmatic learning outcomes, while other sources such as Stassen et al. (2001) suggest 6-8 outcomes. Regardless of the exact number, they should be manageable and written in accordance to the theory discussed in this section.

There are several reasons that departments should create student learning outcomes for their programs. First, most accreditation agencies require SLOs to be included with the other assessment materials (Goucher College, n.d.). By articulating and publishing the outcomes, stakeholders, like accreditation agencies, students, faculty, and administrators, understand what is important to the program. The students become aware of what is expected of them and can better focus their energy on these items (Lindholm, 2009). Specifying the learning outcomes also supports a "learner-centered" approach in the curriculum. "Learner-centered" refers to instruction that focuses on what students should be able to do, rather than simply covering a long list of topics (Lindholm, 2009). Once established, collecting data based on the SLOs can provide information to the faculty on the strengths and weaknesses of the students, thereby improving the effectiveness the educational programs. This insight into the student experience can improve academic advising, encourage course revisions, and suggest program redesigns (Goucher College, n.d.).

The foundation of educational objectives is credited to Bloom and Krathwohl's 1956 publication of *Taxonomy of Educational Objectives*. They state that learning outcomes can be classified into three major domains: affective, psychomotor, and cognitive. The affective domain describes the "changes in interest, attitudes, and values, and the development of appreciations" (Bloom & Krathwohl, 1956, p. 7). The psychomotor domain encompasses physical movements, such as motor-skills, movement, or coordination (Clark, 1999). Finally, the cognitive domain focuses on remembering something that one has previously learned, solving problems, or synthesizing new material. This is the fundamental domain within statistics, since the subject is knowledge-based. In the cognitive domain, there are six levels that begin with the lowest level (knowledge) and move to higher orders (evaluation). The six levels are included in the table below. Since the original work in 1956, many researchers have renamed or revised Bloom's original taxonomy.

Table 1. Bloom's Cognitive Levels

Cognitive Levels	**Description**
Knowledge	Remember material learned in the past
Comprehension	Establish an understanding
Applications	Relate knowledge to pertinent situations
Analysis	Simplify ideas and discover evidence to reinforce generalizations
Synthesis	Assemble ideas into a coherent whole or develop different solutions
Evaluation	Compose and support judgments based on evidence

Note: From Bloom & Krathwohl (1956) and Gordon (2013a)

Also included within the six cognitive levels are related action verbs that are used when writing student learning outcomes. Words such as *learn, understand,* and *master* are considered "fuzzy" or passive verbs and should be replaced with more concrete verbs in outcome statements (Office of Institutional Assessment, n.d.). These passive verbs are fairly common when describing what we want our students to know, but are not measureable. Table 2 below lists several examples of measurable action verbs within each level of Bloom's Taxonomy.

Table 2. Action Verbs

Cognitive Level	Action Verb Examples
Knowledge	Define, describe, identify, label, list, recognize, recall, select
Comprehension	Classify, distinguish, explain, generalize, predict, rewrite, summarize
Application	Apply, change, compute, demonstrate, manipulate, show, solve, write
Analysis	Calculate, compare, criticize, examine, infer, model, outline, relate
Synthesis	Categorize, combine, create, develop, formulate, plan, prepare, tell
Evaluation	Choose, defend, discriminate, estimate, justify, interpret, support, value

Note: Adapted from Stassen et al. (2001), Carr & Hardin (2010), and Gordon (2013a)

There are several characteristics of a good learning outcome. In general, learning outcomes should focus on an action or product, be measurable, and discuss the degree to which they can be obtained (Gordon, 2013a; Lindholm, 2009; UGA Office of Academic Planning, n.d.). In addition, the outcomes should clearly define the condition for measurement (Gordon, 2013a). For example, the outcome: "Students will be able to understand statistical programming" is not measurable, contains a "fuzzy" verb, and does not define any conditions for success. This outcome could be improved, by stating, "Students will be able to write SAS code, without errors, to analyze messy data". The revised outcome uses an action verb, is measurable, and clearly states the desired quality level (Gordon, 2013a).

Stassen, Doherty, & Poe (2001) outline the introductory steps for a department writing new learning objectives. The first step involves creating an open and ongoing discussion with faculty members. This discussion should begin by examining the mission of the university and the program in particular (Schuh & Upcraft, 2001). Next, the discussion should include the characteristics of an ideal student, expectations of graduates, and achievements of alumni. The department should collect and review materials from their courses (such as syllabi, textbooks, and course outcomes) and program descriptions (such as strategic plans and assessment reports). It may also be helpful to review objectives from comparable programs or guidelines from professional organizations. It is important to remember that developing student learning outcomes is an iterative process. Programs typically have to refine and improve outcomes once they try to design an assessment plan (Stassen et al., 2001).

A unique method of writing outcomes is introduced in Jordan, DeGraaf, & DeGraaf (2005) and enhanced by Carr & Hardin (2010). Their method, coined the "ABCD Method," leads to specific and measureable outcomes. The 'A' stands for audience: most commonly in program outcomes this is the student. The 'B' is the behavior or the action verb that will be performed by the audience. The 'C' represents the condition or circumstance under which the behavior will take place. Finally, the 'D' is the degree of competence or the extent of measurement for a student learning outcomes. In her 2013 presentation, the UGA Associate Director of Assessment, Dr. Leslie Gordon discussed a similar approach using the abbreviations ABCC. Very similar to the method discussed by Jordan et. al. (2005), the two Cs in the acronym stand for condition and criteria. Acronyms have been developed at many other institutions, including SMART at the University of Central Florida's Office of Experiential Learning (n.d.). SMART stands for specific, measurable, attainable, results-focused, and time-focused.

2.3 Theory of Curriculum Mapping

Curriculum mapping corresponds to the first step of the Assessment Cycle (see Figure 1) and is a useful method for checking the alignment of learning opportunities to the courses within a program (Suskie, 2009). A curriculum map is a matrix containing a list of courses or electives down the rows and the program learning outcomes across the columns. It is also useful to include program requirements (especially in graduate programs) such as theses, graduation exams, honors presentations, and defenses (URI, 2012). Hatfield (2009) wrote that the mapping process is often "the first time a curriculum has been systematically examined to see how the individual courses function in the curriculum" (p. 3). The curriculum map serves as a general reminder of the student learning outcomes that each course should address. This is especially important since courses are often taught by different instructors. While course level outcomes may vary slightly by instructor, they should not deviate so dramatically that they are no longer mindful of the program level assignments within the curriculum map. This allows the link created between individual courses and program level objectives to hold true regardless of who is teaching the course (Hatfield, 2009).

Creating a curriculum map allows faculty members to see where outcomes are covered in the program and ensures that none can be skipped. In some cases during curriculum mapping, an "orphan outcome," one that not addressed by any course in the progression of classes, is noticed (Stassen et al., 2001). By visualizing outcomes and the courses offered, programs are able to easily identify potential gaps in the curriculum and highlight the deficiencies in a program's graduation requirements (Suskie, 2009). This drives the modifications of existing student learning outcomes as well as potential changes to the curriculum and assessment methods. For example, a common "orphan outcome" is public speaking, because it is often not linked to any course(s) during curriculum mapping. To correct this issue, programs can either eliminate the outcome or redesign a course to integrate public speaking skills. Lastly, the curriculum map shows the progression of student learning (Maki, 2010). Students should not be expected to show high level learning too early (Stassen et al., 2001). Therefore, a progression of learning needs to occur such that students have time to practice an outcome before they are assessed on it. The curriculum map assists in designing the assessment plan, because faculty can see the best opportunities to incorporate assessment into the program.

In curriculum mapping, the progression described above is generally conceptualized in three stages. The first stage, normally called *introduce*, is defined as the focus on basic knowledge, skills, and abilities that support the specific outcome. Introducing a concept provides the building blocks for further learning later on in the sequence of courses (Cal Poly Pomona, 2007; Stassen et al., 2001; URI, 2012). The second stage, called *reinforce*, *develop*, or *demonstrate*, designates courses that strengthen student mastery of an outcome or allow for additional opportunities to practice the outcome (Cal Poly Pomona, 2007; URI, 2012). The third stage, called *emphasize*, *master*, or *assess*, allows for the complex integration of an outcome or an opportunity for assessment (Stassen et al., 2001; URI, 2012). Various sources have discussed the lettering of these stages within a curriculum map. The University of Rhode Island (2012) uses I, R, and E, which stand for introduce, reinforce, and emphasize, respectively. Cal Poly Pomona (2007) use the terms develop or demonstrate to describe the second stage, and then master or assess for the third stage in the sequence. The statistics department at the University of Georgia utilizes the notation published by the Mathematics and Statistics Department at Cal Poly Pomona (2007). Therefore, this report uses introduce, develop, and assess as the three distinctions within the curriculum map.

2.4 Theory of Designing an Assessment Plan

This section provides a roadmap to designing a program assessment plan. With respect to the assessment cycle (see Figure 1), steps 2, 3, and 4 are discussed below. Section 2.4.1 discusses nine principles of good practice for assessing student learning and additional assessment advice provided throughout the literature. Section 2.4.2 distinguishes between eight key assessment terms that are useful to decide on methods. These terms include direct vs. indirect, formative vs. summative, qualitative vs. quantitative, and add-on vs. embedded.

Section 2.4.3 examines many popular assessment methods that programs may want to consider as a part of their assessment plan. Section 2.4.4 focuses on the benefits of adding rubrics to improve existing assessment practices. Section 2.4.5 uses the knowledge of assessment terms and methods to select the best combination items into the overall plan in a process called triangulation. Section 2.4.6 discusses how programs should close the loop of assessment and utilize their data to make meaningful program changes.

2.4.1 Assessment Advice

The current literature offers many pieces of advice for programs in developing effective assessment plans. The nine principles of good practice for assessing student learning written by the American Association for Higher Education (AAHE) are the foundation of this advice. The first three principles focus on establishing clear student learning outcomes that are representative of learning experiences and program purposes (AAHE, 1992). They also reiterate the theory of student learning outcomes provided in Section 2.2. The final six principles provide reminders for programs in assessing their student learning outcomes:

1. The assessment of student learning begins with educational values
2. Assessment is most effective when it reflects an understanding of learning as multidimensional, integrated, and revealed in performance over time
3. Assessment works best when the program it seeks to improve have clear, explicit stated purposes
4. Assessment requires attention to outcomes but also and equally to the experiences that lead to those outcomes
5. Assessment works best when it is ongoing not episodic

6. Assessment fosters wider improvement when representatives from across the educational community are involved
7. Assessment makes a difference when it begins with issues of use and illuminates questions that people really care about
8. Assessment is more likely to lead to improvement when it is part of a larger set of conditions that promote change
9. Through assessment, educators meet responsibilities to students and to the public

The sixth AAHE principle specifies involving the educational community in the assessment process. Assessment can only be effective if it is endorsed by faculty of the program (Lindholm, 2009). Faculty members tend to be skeptical of the process initially and believe that the assessment trend with "blow over" (Hatfield, 2009, p. 2; Peck & Chance, 2007). Often faculty members have so many other things to do that assessment is not high on their priority list (Hatfield, 2009). With regard to faculty involvement in assessment, Peck and Chance (2007) note that it "is surprising…that so many of the decisions that we make as academics are based on personal opinion and anecdotal evidence, and that departments…are often skeptical of attempts to measure the quality of our academic programs" (p. 2). While assessment needs "a collective effort on the part of tenured and non-tenured faculty", it might be best to first establish an assessment committee (Hatfield, 2009, p. 2). This committee can direct the assessment process (Maki, 2010), begin discussions, get department buy-in, and encourage faculty members to see the value of assessment to student learning (Peck & Chance, 2007).

Departmental committees can get started with advice from other program's assessment plans and university resources (Palomba & Banta, 1999). The plans they create should be dynamic, ongoing, systematic, manageable, and generate meaningful data (Hatfield, 2009;

Lindholm, 2009; Palomba & Banta, 1999; Peck & Chance, 2007). An effective plan is designed and implemented by the faculty and is aligned with the curriculum. Successful plans utilize multiple methods and help to distinguish between levels of achievement (Hatfield, 2009; Stassen et al., 2001). Larger programs should also utilize use sampling to reduce the assessment burden (Peck & Chance, 2007). Similarly, programs can focus on assessing only 1 or 2 student learning outcomes per academic year (Gordon, 2013a). Programs deciding on assessment methods need to include a detailed timeline with their assessment plan. This timeline contains the faculty in charge, time frame, resources, and how feedback is used to make changes to the program (Lindholm, 2009). The time frame should allow time for mistakes as well as ongoing reflection, input, and improvement (Palomba & Banta, 1999; Stassen et al., 2001)

2.4.2 Assessment Types

Step 2 of the program assessment cycle focuses on choosing assessment methods. Eight different assessment types can help to distinguish these methods. The biggest distinction in types of assessment methods is between direct and indirect. Direct assessment is defined as "evidence of student learning [that] is tangible, visible, self-explanatory, and compelling evidence of exactly what students have and have not learned" (Suskie, 2009, p. 20). For example, the data collected from course assignments that are graded with rubrics, give direct evidence of student learning.

In comparison, "indirect evidence consists of proxy signs that students are probably learning" and the information gathered, "is less clear and less convincing than direct evidence" (Suskie, 2009, p. 20). Indirect methods often relate to students' perceptions of their skills, rather than actual proof. Student surveys are a common example of indirect evidence because they are self-imposed ratings of student knowledge. It is important to incorporate both direct and indirect evidence when developing an assessment plan, because neither direct nor indirect evidence alone tells "the whole story of student learning" (The Middle States Commission on Higher Education [MSCHE], 2007, p. 31). Direct evidence tells explicitly *what* they have learned, while indirect evidence relates to the process of learning and can provide more insight into *why* they are successful or unsuccessful (MSCHE, 2007). Examples of both types of assessment methods are included in Table 3 below.

Table 3. Examples of Direct and Indirect Assessment Methods

Direct	**Indirect**
• Capstone projects • Senior theses • Exhibits or performances • Pass rates or scores on licensure, certification, or subject area tests • Student publications or conference presentations • Employer and internship supervisor ratings of students' performances • Rubric scores for class assignments or oral presentations • Pre and post tests score gains • Class discussion threads • Student reflections on values, attitudes and beliefs • Course-embedded assignments • Comprehensive or qualifying exams • National, standardized exams • Portfolio evaluation • Case studies • Minute papers or clicker questions • Local objective exams	• Course evaluations (that ask about course – not instructor) • Hours spent on course activities • Focus groups • Course enrollment information • Job placement and employer surveys • Alumni surveys • Proportion of upper level courses compared to other institutions • Graduate school placement rates • Transcript studies • Exit surveys • Satisfaction surveys • Graduation and retention rates • Study abroad percentages • Syllabus assessment • Midterm feedback from students • Course grades, GPA data, enrollment figures, time to degree • Assignment grades (without rubrics) • Student ratings of knowledge or skills • Honors and award by students/alumni • Observing students' behaviors

Note: Adapted from Suskie (2009), Jonson (2006), Middle States Commission on Higher Education [MSCHE] (2007), and Office of Institutional Assessment (n.d.)

Grades are also generally an example of indirect evidence. This is the case because standards are not necessarily consistent and information may not precisely reflect student learning (Gordon, 2013b). Stassen et al. (2001) state that "because grades don't tell you about student performance on individual (or specific) learning goals or outcomes, they provide little information on the overall success of the program in helping students attain specific and distinct learning objectives of interest" (p. 30). Grades can only be considered an example of direct evidence when they are generated from specific criteria and have an immediate relation to learning goals (MSCHE, 2007). An example of this instance is when programs use rubrics to assess student learning and assign grades. The use of rubrics in assessment is discussed in Section 2.4.4.

Another distinction between types of assessment is whether it is summative or formative assessment, which may also be called outcomes and processes, respectively (Gordon, 2013b; Suskie, 2009). Summative assessment is conducted at the end of a course or is an *outcome* of a program. Examples of summative assessments include final exam grades or a cumulative portfolio. On the other hand, formative assessment is conducted in the middle of a course or program, while students are in the *process* of developing mastery of the outcome. This type of assessment allows faculty members to adapt the course immediately in concordance with student growth (Suskie, 2009). A professor who uses the results of a first project to change the path of the course or discuss a misunderstood topic in more detail, is completing formative assessment (MSCHE, 2007). Some assessment methods, like projects, could be summative or formative, depending on their location and purpose within a course. A project completed during the middle of the semester is a formative assessment measure, while a final project would be summative. Like direct and indirect measures, "formative and summative assessment work together to improve learning" (MSCHE, 2007, p. 27).

Additionally, the literature distinguishes between embedded and add-on assessment methods. Embedded assessments are integrated into courses: serving double duty as program assessment items and course assignments. Embedded assignments include objective tests, projects, or in-class performances that can provide insight into the functionality of the program as a whole (Suskie, 2009). Incorporating embedded assignments into the classroom also helps in getting true responses from students (Peck & Chance, 2007). Students in the research were more serious when their responses counted toward a grade when compared to responses on an add-on exit survey (Peck and Chance, 2007). Add-on assessments are not part of course syllabi and do not affect a student's grade in any specific course (Suskie, 2009). Add-on assessments may also be included as an item that students must complete before graduation, such as a graduating student exit survey. Some examples of add-on assessments are portfolios or focus groups (Suskie, 2009; Gordon, 2013b).

Assessment methods and their resulting data follow two types, quantitative and qualitative. Quantitative assessment methods produce specific responses and data that can be analyzed with statistical methods (Suskie, 2009). The number of responses that are correct and incorrect provide interpretable information on student knowledge (Maki, 2010). Examples of quantitative assessment include test scores, rubrics, and ratings from surveys. Qualitative assessment methods are more flexible and look for recurring patterns in student work (Suskie, 2009). This type of assessment incorporates a broader understanding of learning; however some error is possible due to the interpretations of the spectator (Maki, 2010). Examples of qualitative assessments include focus groups, notes from interviews, and other observations. Both qualitative and quantitative methods are highly valued and should be combined in order to create stronger assessment plans (Schuh & Upcraft, 2001).

A summary of the assessment types explained in this section is provided in the Table below. In the following sections, Section 2.4.3 will discuss the most common assessment methods and Section 2.4.4 will discuss the importance of using a combination of assessment types when selecting methods.

Table 4. Summary of Assessment Types

Assessment Type	Definition
Direct	Tangible or convincing evidence of student understanding
Indirect	Perceptions or probable evidence of student learning
Formative	Conducted in the middle of a course and used to make changes
Summative	Conducted at the end of a course or program
Add-on	Added to a program and not required for any specific course
Embedded	Integrated into courses as course and program assessment
Quantitative	Specific responses and data that can be analyzed with statistics
Qualitative	Flexible responses and data that is analyzed based on patterns

2.4.3 Popular Assessment Methods

There are many methods that programs can use to assess student learning either within programs or within individual courses. Assessment methods can easily be added-on to programs or embedded through regular course assignments. It is up to each department to decide on the most useful and manageable methods. Table 5 matches the assessment types discussed in Section 2.4.2 with the popular assessment methods that are discussed in this section. This section also describes the advantages and disadvantages to some of the most commonly used assessment methods.

Table 5. Attributes of Assessment Methods

Assessment Method	Direct vs. Indirect	Formative vs. Summative	Add-on vs. Embedded	Qualitative vs. Quantitative
Records of student data	Indirect	Formative	Add-on	Both
Syllabus analysis	Indirect	Formative	Add-on	Qualitative
Exit interviews	Indirect	Summative	Add-on	Both
Focus groups	Indirect	Formative	Add-on	Qualitative
Portfolios	Direct	Summative	Add-on	Qualitative
Alumni surveys	Indirect	Summative	Add-on	Both
Employer surveys	Indirect	Summative	Add-on	Both
In-class assignments	Direct	Both	Embedded	Both
Objective tests	Direct	Both	Embedded	Quantitative
Posters	Direct	Both	Embedded	Qualitative
Presentations	Direct	Both	Embedded	Qualitative
Papers	Direct	Both	Embedded	Qualitative

There are a variety of add-on assessment methods that can be attached to a program. They include, but are not limited to, records of student data, syllabus analysis, exit interviews, focus groups, portfolios, and surveys. A standard component of an assessment program is an ongoing record of student data. It is an easy item to incorporate into an assessment plan because the information is likely already available to programs. Records of student data could include: number of graduates, majors, and minors, grade records from courses, performances on actuarial, certification exams, or GRE, lists of student honors and awards, and internship information (Groeneveld & Stephenson, 1999). It may be helpful to include job and graduate school placement rates, as well as the specifics of the positions or programs that students attend after graduation (MSCHE, 2007). Collecting these data allows departments to understand the demographics of their program as well as any trends in student achievement. While records of student data may help departments to understand their programs as a whole, this information is indirect, and therefore does not demonstrate actual learning (MSCHE, 2007). In an assessment plan, records of student data "can be useful to the extent that they correlate with and illuminate direct learning assessments" (MSCHE, 2007, p. 53).

Syllabus analysis is another indirect, add-on assessment method that can be incorporated into current departmental procedures. During syllabus analysis, faculty members review curriculum syllabi to see if there are enough opportunities for students to practice the learning outcomes (Suskie, 2009). This should be undertaken about every five years in order to understand how individual faculty members are implementing the selected program learning outcomes in their courses. Syllabus analysis is a useful process and is very similar to curriculum mapping because it promotes coherence across the department and helps to identify possible areas for improvement. Many programs ignore this type of assessment method because it is time consuming and sometimes difficult to get faculty member involvement. Syllabus analysis is also useless if students or the faculty teaching the course each year do not use the syllabus as a learning guide (Jonson, 2006).

Another example of an add-on assessment method is exit interviews that are required from each graduating student. They are a summative assessment method that can generate both qualitative and quantitative data. Exit interviews ask students to respond to a set of open and closed questions about their experiences within the program. They are inexpensive, easy to administer, and are used to track student opinions over time. Poorly written prompts, however, result in insufficient student responses. This leaves a lot of the success of the interview in the hands of the interviewer (Stassen et al., 2001). With a trained interviewer, exit interviews can provide a realistic and in-depth perspective of student experience (Jonson, 2006).

Focus groups are an extension of an exit interview. They are carefully structured discussions that allow groups of six to ten students to discuss their knowledge and experiences.

Focus groups are increasing in popularity because they "provide an excellent opportunity to listen to the voices of students, explore issues in depth, and obtain insights that might not occur without they discussion they provide" (Palomba & Banta, 1999, p. 196-197). Focus groups provide a wide variety of data, with immediate impact (Stassen et al., 2001). The open-ended nature of focus groups may also bring up areas of concern that were not originally foreseen by faculty members or other assessment methods (Jonson, 2006). MSCHE (2007) agrees, saying that "focus groups are usually most appropriate as tools to help illuminate other assessment results, rather than as stand-alone assessment strategies". Like exit interviews, the success of this assessment method is highly dependent on the moderator and the department's ability to gather enough participants (Stassen et al., 2001; Suskie, 2009). Focus groups are not a good source of quantitative data; they provide qualitative data that can be time consuming to analyze (Schuh & Upcraft, 2001; Suskie, 2009). Additionally, focus groups with current students might be unsuccessful if students feel there will be retribution in response to a critical evaluation of the program (Jonson, 2006).

Portfolios are another popular example of an add-on assessment method (MSCHE, 2007). Unlike previous add-on methods, portfolios are direct assessment methods that can be incorporated into a program. Portfolios are collections of student work that can include papers, reports, exams, or analyses (Stassen et al., 2001). It is essential that portfolios also include student reflections detailing the reasons for inclusion and discussion of each contributed item (Suskie, 2009). Portfolios allow programs to see to the trends in student growth over time, as well as students' overall strengths and weaknesses (Jonson, 2006). They can also serve as valuable resources for students applying to jobs or graduate school and allow students to take greater responsibility for their work. For a program, portfolios can be difficult to store, costly, time consuming, and require extra work by the faculty (Stassen et al., 2001). Taking this into account, portfolios are best suited for programs with a smaller number of students (MSCHE, 2007; Suskie, 2009). The information contained in portfolios must be converted to meaningful assessment data, which requires faculty resources that are demanded elsewhere (Jonson, 2006).

Surveys are another indirect, add-on assessment method that are conducted with alumni or employers. Alumni surveys ask the program's graduates about their current positions and any skills that they use in their jobs on a regular basis. The patterns of commonly used skills that are not addressed in the program, suggest ways in which a curriculum should be changed (Stassen et al., 2001). Alumni surveys are broad in scope and are inexpensive measures of student experiences (Stassen et al., 2001). They are sent to people who have interest in helping the program and are knowledgeable of its strengths and weaknesses. Sending out alumni surveys may also prompt the alumni to donate money or forward job openings within their companies. Unfortunately, alumni surveys have notoriously low response rates and it is often very difficult to locate students after graduation (Jonson, 2006). Additionally, programs thinking about using surveys should be mindful of Institutional Review Board (IRB) requirements (Jonson, 2006). A similar type of survey can be sent to employers or company recruiters. This survey can be used to ask about desired job skills for students who will graduate from the program. Current employers or recruiters provide unique insights (Palomba & Banta, 1999) into valued skills that cannot be replicated with any on campus assessment method (Stassen et al., 2001). Unfortunately obtaining a good response rate or contacting willing employers is difficult and time consuming. Both types of surveys, alumni and employer, must be carefully constructed in order to get useful data in return (Stassen et al., 2001).

It may be easier to assess student learning by incorporating assignments into classes or capstone courses through embedded assignments. Course embedded assignments are either regular class activities or assessment specific items that are seamlessly integrated into a course (Jonson, 2006; Stassen et al., 2001). Embedded assignments are authentic representations of student knowledge that are convenient and typically easy to administer (Jonson, 2006; Stassen et al., 2001). These assessment methods include in-class assignments, objective tests, papers, posters, or performances.

Options for conducting in-class embedded assignments include discussion board posts, free-writing, or minute papers. These short assignments provide immediate feedback to faculty and little intrusion into courses (Jonson, 2006). Course embedded assignments may take a lot of time to prepare and there is little documentation on their true value to assessment (Stassen et al., 2001). Embedded assignments of this type should be used in combination with other assessment measures in order to provide a complete view of student understanding (Jonson, 2006). Palomba and Banta (1999) point out that when individual teachers conduct classroom assessment, “it is a challenge to get the results to add up to a coherent picture of what is going on in a program” (p. 176). This disconnect should encourage faculty discussion on the alignment of course and program goals throughout the curriculum (Jonson, 2006).

Embedded assessment methods also include objective tests that are typically part of normal course assessment. Classroom tests are a direct type of assessment and include nationally standardized and locally developed instruments with multiple choice or true/false questions (Palomba & Banta, 1999). Both types of tests check for basic competencies and allow programs to compare student achievement after taking the same test (Maki, 2010). National tests are advantageous because they allow the examination of a large group of students in a short time frame (Palomba & Banta, 1999). Another advantage of national tests is that they are exposed to reliability, validity, and other psychometric studies (Jonson, 2006; Maki, 2010). National, standardized tests however are often not directly aligned with program learning outcomes and typically fail to provide realistic insight into problem solving processes (Maki, 2010). This type of test is generally used for the certification of professional skills as mandated by external requirements. Often there are no national standardized tests that are appropriate within individual courses (Maki, 2010). In this case, local exams are developed to better integrate course and program level student learning outcomes. Local exams, however, may be difficult to create and may suffer from poor quality questions (Jonson, 2006; Palomba & Banta, 1999). Overall, national and local tests are only able to examine low-level knowledge (Jonson, 2006).

Capstone courses serve as an appropriate location for assessing student learning outcomes in an undergraduate program (Palomba & Banta, 1999). According to the Macalester College Catalog (2012), capstone courses are designed to "give students experience with reading original research literature, doing original work, or presenting a performance". This type of course is growing in popularity and serves as a comprehensive experience for graduating seniors (Palomba & Banta, 1999). Because capstones are typically a required course, they are the perfect place to assess the knowledge of graduates. In contrast to objective tests, capstone courses provide opportunities to assess student learning at a higher level (Maki, 2010). In this type of culminating course, students are able to demonstrate synthesis and evaluation of cognitive abilities (Bloom & Krathwohl, 1956).

Capstone courses, as well as other courses throughout the curriculum, can utilize posters, presentations, and/or papers to assess student learning. All three methods are direct, embedded, and can be either summative or formative. Posters, through an individual or team effort, serve as a visual depiction of student work. When included in a departmental poster session, students can practice summarizing their work to attendees. Including an award in poster sessions can also greatly increase student motivation. Posters reduce the grading burden as compared to papers and better integrate communication skills (Jonson, 2006). Unfortunately, posters and the groups presenting them may be handicapped if their displays are not aesthetically pleasing (Jonson, 2006).

Oral presentations are often a difficult and fear-inducing task for many students (Jonson, 2006). Students are forced to think on their feet and practice crucial communication skills. International students or students with language difficulties, however, are at a notable disadvantage regardless of their underlying knowledge. Poor quality presentations are often a waste of time, and professors find it difficult to grade fairly the performances (Jonson, 2006). Papers are another method to track student learning and enhance critical communication skills. Students are able to write multiple drafts of their paper and receive feedback throughout the process. This is very useful, but labor intensive for the faculty involved (Jonson, 2006).

2.4.4 Utilizing Rubrics in Assessment

Many programs already include projects, presentations, or papers in their courses, but adding a rubric to these items can aid in program assessment (Stassen et al., 2001). Consider, for example, course papers, which are a qualitative and direct assessment method. While papers certainly demonstrate individual student learning, it is difficult to use papers written by individual students to understand the collective knowledge of the group. This makes it difficult to determine, using the papers, whether or not the program's student learning outcomes are being mastered. When grades are assigned to papers, this value is quantitative and indirect. Grades are a subjective measurement and do not show exactly what students know. As seen in Figure 2, rubrics can combine the learning that is demonstrated in papers and the scoring system that is needed in grading. Therefore, rubrics help to bridge the gap between course assignments and program assessments by allowing instructors to grade papers and assess student learning outcomes at the same time.

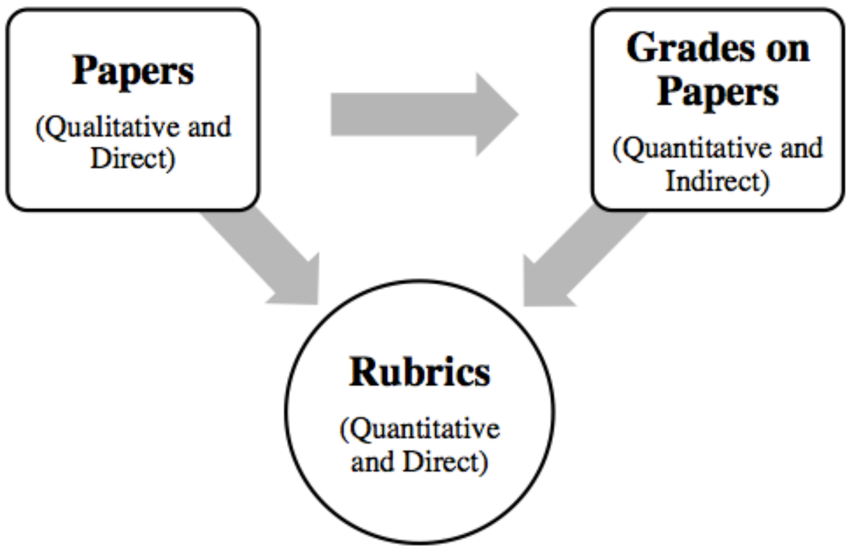

Figure 2. Rubrics as Assessment Methods

Rubrics are scoring tools that identify specific criteria that students should meet for a particular assignment (Quick, 2014). Rubrics are useful because they can be shared with students, are efficient, and can create consistency across products (Mullinix, 2009). They also provide enhanced feedback to faculty, by showing whether or not students can apply the outcomes in practice (Suskie, 2009). Developing a rubric, however, is time consuming and requires the raters to be trained to ensure consistency of scores (Stassen et al., 2001). There are two main types of rubric scoring systems, holistic and analytic. Holistic scoring focuses on an overall impression where elements are combined (Quick, 2014). This type of rubric is especially useful to programs that wish to categorize student performances into levels (Maki, 2010). An example of a holistic rubric for a presentation is included in Table 6 below. In this example, a presentation could be categorized into one of three levels using the criteria in each section.

Table 6. Example Holistic Rubric

3	Student does almost all of the following: • Full understanding of material and complete answers to questions. • Presentation is logical and interesting for audience. • Images are explained and useful to the presentation. • Maintains constant eye contact and uses slides sparingly.
2	Student does almost all of the following: • Solid understanding of material and adequate answers to questions. • Presentation can be followed, but dull for audience. • Images are useful to the presentation. • Maintains partial eye contact and uses slides too frequently.
1	Student does almost all of the following: • Incomplete understanding of the material and basic answers to questions. • Presentation jumps around and is not easy to follow. • Images are not used or are not useful to the presentation. • Maintains little to no eye contact and reads off slides.

On the other hand, analytic rubrics or descriptive rubrics provide detailed insight into student performance by examining elements separately at each level (Maki, 2010; Suskie, 2009; Quick, 2014). This type of scoring system is typically in matrix form and is very useful in determining the particular strengths and weaknesses of student work (Maki, 2010; Quick, 2014). An example of an analytic rubric for a presentation is included in Table 7 below.

Table 7. Example Analytic Rubric

	1 Novice	2 Intermediate	3 Advanced
Content	Incomplete understanding of the material and basic answers to questions.	Solid understanding of material and adequate answers to questions.	Full understanding of material and complete answers to questions.
Organization	Presentation jumps around and is not easy to follow.	Presentation can be followed, but dull for audience.	Presentation is logical and interesting for audience.
Graphics	Images are not used or are not useful to the presentation.	Images are useful to the presentation.	Images are explained and useful to the presentation.
Eye Contact	Maintains little to no eye contact and reads off slides.	Maintains partial eye contact and uses slides too frequently.	Maintains constant eye contact and uses slides sparingly.

Note: Adapted from Stevens and Levi (2005)

In his 2014 workshop on creating rubrics, Paul Quick discusses the four parts of an analytic rubric: task, scale, elements, and description. The task is the complete description of the assignment and its inclusion in the rubric is optional. The scale, which defines the levels of student achievement from lowest to highest, is placed horizontally. Typically there should be 3 – 5 levels of student achievement. The example given in Table 7 contains three levels: novice, intermediate, and advanced. Examples of other scales include “high”, “middle”, “beginning”; “advanced”, “intermediate”, “novice”; or numbered scales. The descriptions should contain positive terms with a clear distinction between levels (Hatfield, 2009; Quick, 2014). The next part of a rubric is the performance elements or dimensions. They are included on the left side of a rubric and break down the attributes of students’ work or the core learning areas. The four performance elements included in the example in Table 7 are content, organization, graphics, and eye content. Lastly, the descriptions are the interior cell components that detail the specific attributes for the intersection of the scales and elements. While initially complicated to set up, rubrics are extremely useful "to assess work and discuss how to improve it" (Mullinix, 2009).

Both analytic and holistic rubrics can be adapted to match the learning outcomes of any program. When using a holistic rubric, the criteria within each level should detail the progression of one or more learning outcomes. This allows departments to categorize the overall level of student achievement. When using an analytic rubric, the dimensions across the rows could be customized. In Table 7, *organization* and *eye contact* would be related to a communication based SLO. The dimensions could also be the student learning outcomes themselves, with further details provided in the interior descriptions. This type of rubric provides more precise information on student achievement within each of the core areas. Regardless of the type, rubrics are a valuable, direct assessment method that can be used to gain information on student learning.

2.4.5 Deciding on Assessment Methods

Departments should select the assessment methods that will be the most useful for gathering information on student learning outcomes. According to Suskie (2009), "every assessment strategy has potential value" (p. 34), but faculty need to find what works best for their program. The best combination of methods, answers important questions, is manageable based on current resources, and allows faculty to view the strengths and weaknesses of the program (Stassen et al., 2001). The process of selecting multiple assessment types is called triangulating assessments (Washington State University (WSU), 2009). Assessment plans should include both direct and indirect methods, as well as qualitative and quantitative methods. Triangulation helps to better assess a complex task and to tell faculty about student experiences throughout the curriculum (Palomba & Banta, 1999). Using multiple methods and assessment types is advantageous because it gives students a variety of opportunities to display what they have learned (Maki, 2010). Within an assessment plan, ideas are reinforced when multiple methods point to the same findings and ideas are challenged when multiple methods disagree (Stassen et al., 2001).

An assessment matrix can be used to choose appropriate assessment methods (Palomba and Banta, 1999; Stassen et al., 2001). Two types of matrices are helpful: a selection criteria matrix or an objectives-by-measures matrix. The selection criteria matrix identifies important factors in deciding on which assessment measures to use, such as: measures that match the curriculum, can be prepared in a reasonable timeframe, are manageable in cost, and are valuable to student learning. The selection criteria matrix is then used to link the assessment measures with these factors. An example of this matrix is included in the table below. Using Table 8, a capstone paper appears to be both a feasible and valuable assessment method, while a portfolio is not. Therefore, the selection criteria matrix can help departments with limited resources maximize the functionality of their assessment plan.

Table 8. Example Selection Criteria Matrix

	Portfolios	Alumni Survey	Capstone Paper
Matches curriculum			✔
Reasonable timeframe		✔	✔
Manageable in cost		✔	✔
Valuable to student learning			✔
Generates meaningful data	✔	✔	✔

The objectives-by-measures matrix links existing or future assessment measures with student learning outcomes. This type of matrix is important to identify what assessment information is already being collected before working on a new assessment plan (Stassen et al., 2001). The matrix, similar to the curriculum map discussed in Section 2.3, helps to link assessment tools with program goals. Creating a matrix helps programs to select assessment measures based on their program goals, rather than forcing outcomes to existing assessment methods. It allows programs to see where certain questions fail to be answered or where learning outcomes are not triangulated with multiple measures. An example of this matrix is included in Table 9. In this example, the portfolio would be a very useful assessment method because it addresses all of the student learning outcomes and is triangulated with multiple assessment types. The alumni survey fails to address any of the outcomes and would not be a useful assessment method.

Table 9. Example Objectives-by-Measures Matrix

	Portfolios	Alumni Survey	Capstone Paper
Method Type	Direct	Indirect	Direct
SLO 1	✔		✔
SLO 2	✔		✔
SLO 3	✔		

2.4.6 Closing the Loop

Once the data have been collected, the important work of understanding how well the curricula match with educational objectives begins. This final step in the assessment cycle is often the biggest challenge. Hatfield (2009) states, "it is not uncommon for data to be collected only to be ignored thereafter… [however] it is not until the data has [sic] been analyzed, discussed, and used as a basis for further program improvement that assessment has taken place" (p. 6). Analysis of program assessment data over time reveals three common patterns. They are distinguished as patterns of consensus, patterns of consistency, and patterns of distinctiveness (Hatfield, 2009). Patterns of consensus occur when disaggregating the data exposes agreement between items. Looking at the same type of data over an extended period of time reveals patterns of consistency. Lastly, looking at data across various outcomes to see which outcomes perform the best, shows patterns of distinctiveness. Upon identifying patterns, programs can classify the trend, determine whether the achievements are acceptable, and discuss any surprises (Hatfield, 2009). The term "closing the loop" (Gordon, 2013b; Hatfield, 2009) is an assessment cliché that describes the changes that are encouraged by the patterns in the data. Programs should use data to influence curricular reform when the true and desired performances are not in concordance. Sometimes data suggest that departmental policies should be reviewed. This could include advising methods, admissions criteria, or methods for managing students through the curriculum. Most importantly, assessment data should encourage faculty discussion about student learning and programs as a whole.

2.5 Student Learning Outcomes in Statistics

In 2000, the American Statistical Association (ASA) composed the Curriculum Guidelines for Undergraduate Programs in Statistical Science. This list contains the recommended principles, skills needed, and curriculum topics for college statistics programs. It is interesting that the guidelines state that an "undergraduate program is not intended to train professional statisticians" (American Statistical Association [ASA], 2000). In addition, the ASA suggests that programs include practical experience by incorporating some type of capstone course, internship, senior project, or consulting experience.

The guidelines established by the American Statistical Association are not strict rules, but they serve as suggestions for undergraduate programs. The ASA's principles state that statistics programs should be flexible enough to fit within institutional constraints and satisfy students with a variety of long-term goals (including employment, focuses in other fields, and graduate school). The programs should expand upon the material learned in introductory courses, while incorporating real data. The guidelines also make the distinction between statistics and mathematics disciplines, since curricula for the former should include nonmathematical topics. The skills suggested for a statistics curriculum are combined into five areas: statistical, mathematical, computational, nonmathematical, and a substantive area. The skills and their descriptions are included in Table 10 below. For those students who plan to go on to graduate work, it is essential to include more mathematics courses in their plan of study.

Table 10. Skills Needed by Undergraduate Majors

Skills	**Description**
Statistical	Training in statistical reasoning, designing studies, exploratory analysis of data, formal inference procedures
Mathematical	Probability, statistical theory, prerequisite mathematics (specifically calculus and linear algebra)
Computational	Familiarity with standard statistical software packages, data management, algorithmic problem solving
Nonmathematical	Write clearly, speak fluently, collaboration skills, teamwork, managing projects
Substantive Area	Depth in an area of application

Note: From ASA (2000)

The guidelines also set forth a list of curriculum topics for the undergraduate degree in statistical science. The curriculum topics are consistent with the skills in Table 10, but include additional details for the statistical component and include probability instead of a substantive area. Curricula should include statistical topics such as point and interval estimation, hypothesis testing, graphing data, logistic regression, categorical data, random sampling, analysis of variance, and stratification. With respect to probability, courses should emphasize "connections between concepts and their applications to statistics" (ASA, 2000). To include additional topics, programs should choose electives the offering of which are feasible for their institution. If it is helpful or possible, institutions can also tailor their programs to four industries:

industry/manufacturing/engineering, medical, business/management, and government (Bryce, et al., 2000).

The 2014 President of the ASA, Dr. Nat Schenker, created a workgroup to revise the previous guidelines established in 2000. A webinar series was also launched to stimulate discussions about necessary changes to the guidelines. During the fall of 2013, four webinars were conducted each focusing on one aspect relating to undergraduate statistics programs: large programs, big data, capstone courses, and community colleges. In the first webinar, representatives from large programs discussed their methods for teaching their students the "soft skills" of communication and technical writing. Many colleges have increased their focus on communication and technical writing, through either existing or additional courses (Horton, 2013). From the webinar discussions, one can anticipate that the ASA curriculum topics are likely to remain similar to the five skill categories identified in the 2000 document. The biggest change is expected in the computational section due to the rise of prominence of the area of big data within the discipline of statistics. Other feedback on the ASA guidelines suggested the incorporation of mathematical modeling, messy or inaccurate data, and/or database expertise (Horton, 2013). The guidelines will be updated after Summer 2014, with initial recommendations being presented at the 2014 Joint Statistical Meeting.

2.6 Assessment in Statistics

In a 2005 presentation at the Joint Statistics Meetings, Peck and Chance (2007) discussed the programmatic assessment experience of the Statistics Department at Cal Poly San Luis Obispo. The department began with a bulleted list of 77 content topics from the courses in their program. Once they viewed the curriculum as a single entity, they were able to narrow down the list to six main objectives. By discussing and reducing the objectives, the department was able "to create a shared vision of program goals" (p. 3). Their second step was to collect baseline data using an exit survey given in the capstone course. They were mainly interested in seeing if students could chose a correct method of analysis, understand sampling variability, and explain the meaning of a p-value. Peck and Chance describe the results as "a bit depressing" and an eye-opening experience. They found that most students were unable to explain p-values to someone without a statistical background. Overall, the survey showed that key aspects of their curriculum were not being met. Students were confident of their understanding of a topic, but could not demonstrate this knowledge. The department at Cal Poly San Luis Obispo has continued the assessment process and is now able to review their data for trends in student learning. They discuss the results each year at their fall department retreat.

The Statistics Department at Iowa State University discussed their assessment plan in a 1999 report by Groeneveld and Stephenson. The faculty agreed on five statements of the knowledge, skills, and abilities that were expected of their graduates. The corresponding assessment plan consisted of grade distributions, records of student internships and future plans, a survey of employers, and an alumni questionnaire. When looking at the overall grade distributions, the department found that students have the most difficulty in the theory courses. Through the employer survey, the department learned that the students had a solid work ethic, but were unable to apply and communicate statistics. The graduates agreed, saying they needed more help developing their oral and written communication skills. As a result of the assessment, the department at Iowa State updated their computer workstations, redesigned their sampling course, and added two required communications courses.

The Office of Assessment at the University of Rochester (2014) outlines the assessment plan for the Bachelor of Science Degree in Applied Mathematics. Their plan is very reasonable for medium-sized departments to implement and uses a combination of both direct and indirect assessment measures. To gauge student learning, the department first conducts a syllabus analysis by matching the expectations of their courses to the program as a whole. Each year, they select one student learning outcome to highlight for assessment. This outcome is reviewed through course embedded assignments where students are expected to show mastery of the topic. Every year the department gives the graduating students a senior survey and every five years an alumni survey is conducted. These surveys record employment, graduate school rates, awards, and scholarships. With respect to indirect measures, the department looks at the satisfaction and self-assessment ratings from the two surveys. They also conduct a bi-annual focus group to review the program. The data collected through the University of Rochester's assessment plan are reviewed annually by the department's undergraduate committee.

The experiences of Cal Poly San Luis Obispo, Iowa State University, and the University of Rochester provide useful insight into the practical ways to introduce assessment into undergraduate statistics programs.

CHAPTER 3

LOCAL SITUATION

3.1 UGA Assessment Process

The cycle of assessment varies at each individual institution. This section summarizes the requirements for reports in the seven-year review cycle at the University of Georgia provided by the Office of Academic Planning (OAP) (n.d.). A visual of this cycle is included in Figure 3. Each department is required to submit brief reports in years 1, 2, 4, and 5. These brief reports are 1-2 page summaries of the assessment data collected during the previous year. Brief reports only need to include discussion of one-third of the student learning outcomes that are set by the program. In years 3 and 6, full reports are submitted. A full report contains information about all student learning outcomes and includes assessment data collected from the past year as well as from previous brief reports. Both report types are due to the Office of Academic Planning by October 1st. Full program reviews occur during the 7th year of the cycle and are conducted by the Program Review and Assessment Committee (PRAC).

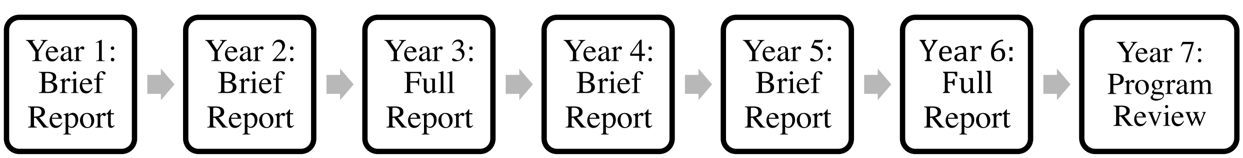

Figure 3. UGA Program Review Cycle

During the full program review, PRAC uses seven criteria (OAP, n.d.) to assess a program's student learning outcomes, assessment measures, and data collected:

1. Clearly defined SLOs that are also measureable
2. Assessment measures address the degree to which students obtain SLOs
3. Assessment measures are independent of grades and teaching evaluations
4. Multiple assessment methods are used
5. Data are collected over time
6. Data result in findings relevant to program
7. Improvements are planned and implemented

3.2 Our Department

The University of Georgia (UGA) was founded in 1785 as the first state-chartered university in the United States. UGA is located in Athens, Georgia, sixty miles northeast of downtown Atlanta. There are a total of 35,000 students and specifically 26,000 undergraduates (Public Affairs Division, 2013). In 1964, the Department of Statistics was formally established and has grown dramatically over the years. As of 2012, there were 24 faculty members (18 tenure-track and 6 nontenure-track), 4 adjunct appointees, and 4 staff members (Stufken & Taylor, 2013). A 2012 report by Franklin, the Department of Statistics Undergraduate Coordinator at UGA, discussed the purposes of the undergraduate program. The primary purpose is to provide students with a strong statistical background that will lead to a Bachelor of Science degree and prepare students for a career after graduation. Additionally, the department is responsible for teaching core classes to students across the university. These courses include introductory statistics, business statistics, statistics for math educators, and two honors courses.

Between 1964 and 2010, the undergraduate program at UGA has awarded 493 bachelor's degrees (Stufken & Taylor, 2013). In addition to their statistical studies, many of the graduates of the program have double majors and/or minors. In 2012, there were approximately 75-80 students majoring in statistics and there were approximately 100 in 2013. Below is a table of the recent degrees conferred since Spring 2012.

Table 11. Bachelor of Science Degrees Conferred

	Spring 2012	Summer 2012	Fall 2012	Spring 2013	Summer 2013	Fall 2013
BS Degree	8	2	1	18	1	4

Note: From C. Franklin (personal communication, March 17, 2014)

The Bachelor of Science degree in Statistics requires a minimum of sixty hours of coursework. The prerequisites for statistics majors include STAT 2000, a computer science course, and a calculus sequence. The required statistics courses are included in Table 12. The curriculum is designed to be flexible enough to allow students to choose courses based on their future aspirations (Franklin, 2012). For example, students interested in pursuing graduate school are encouraged to take an additional course in linear algebra (Department of Statistics, n.d.).

Table 12. UGA Requirements for Bachelor of Science in Statistics

Required Courses		**Elective Courses**	
STAT 4210 or STAT 4110H	Statistical Methods	STAT 4100	Applied Stochastic Processes
STAT 4220	Applied Experimental Design	STAT 4240	Sampling and Survey Methods
STAT 4230	Regression Analysis Methods	STAT 4260	Statistical Quality Assurance
STAT 4360	Statistical Programming	STAT 4280	Applied Time Series
STAT 4510	Mathematical Statistics I	STAT 4290	Nonparametric Methods
STAT 4520	Mathematical Statistics II	STAT 4380	Survival Analysis
STAT 5010	Capstone I	STAT 4630	Stat Method Bioinformatics I
STAT 5020	Capstone II	STAT 4640	Stat Method Bioinformatics II

Note: From Department of Statistics (n.d.)

The capstone courses (STAT 5010 and 5020) were introduced during the 2007-2008 academic year as a six-credit sequence (Lazar, Reeves, & Franklin, 2011). The two courses are taken during students' senior year and expose students to real data problems. Students work with clients to investigate research questions, while gaining experience that could not be acquired in a traditional classroom setting. The UGA capstone sequence has been so successful that it was featured at the 2012 Joint Statistical Meetings as well as an ASA webinar in 2013. Over the years, the capstone classes have established three major themes (Lazar et al., 2011, p. 183):

1) Teaching advanced/modern statistical methods to undergraduate statistics students;
2) Giving these students an intensive, year-long data analysis experience; and
3) Providing the students with an opportunity to improve their written and oral communication skills

3.3 Previous Work by Our Department

On December 10, 2002, the faculty unanimously approved the major assessment plan of the undergraduate statistics major. The report by Franklin (2003) states that the main goal of the assessment plan is:

> To see how well the undergraduate statistics major curriculum teaches students the fundamental concepts of working with data and the quantitative skills needed to prepare them for a career using statistics and/or to further their education in the field of statistics. (p. 1)

Implemented starting in 2003, the current assessment plan had four main components. Part 1 is an assessment based on student performances in essential courses. The instructors of these courses compile a roster of grades, exam scores, and assignments. They also provide a brief statement on the strengths and weaknesses of each student to the department head. The undergraduate committee then meets with the department head to discuss any issues that have arisen as a result of the student performance summaries. Students are considered successful with grades of a C or better in their courses. Part 2 of the current assessment plan is an assessment based on student portfolios that combine work from three to five courses. Students include data analysis projects, essays, and power point presentations as well as an explanation of why each item was included. Part 3 is a combination of surveys and exit interviews. The first survey is an alumni survey that is mailed together with the annual departmental newsletter. Another survey is sent to current students to get their feedback on the undergraduate program. Finally, the department administers an oral exit interview to every student prior to graduation. In the exit interview students discuss the knowledge that they gained in the program and provide feedback on their undergraduate experiences. Part 4 of the assessment plan consists of an annual faculty analysis of the surveys and results collected during the program assessment process.

The last full review of the Department of Statistics using this assessment plan occurred during the 2012-2013 academic year. The 2012 report by Franklin describes the purposes, strengths, weaknesses, and curriculum changes that were made to the undergraduate program in the last seven years. During this time frame, the department added the capstone course, separated the mathematical statistics courses (STAT 4510 and 4520) from the master's level courses, and incorporated both SAS and R into the programming course (STAT 4360). Departmental strengths mentioned in the surveys include small class sizes in 4000 level courses, accessible faculty, the capstone courses, and the sense of community within the department for undergraduate students. Another strength is the growth in the number of undergraduate students within the major and those earning a minor in mathematics. Additionally, the department has been able to offer a diverse curriculum where students can gain mathematical, computing, and communication skills. Current department weaknesses include lack of contact with alumni, a deficit in student achievement of maturity in higher-level mathematics early in their academic careers, and having enough seats in courses to meet the growing demand. The undergraduate program also has difficulties balancing the differences between majors and non-majors in terms of abilities, long-term goals, or 'things they need to learn from the course to be successful after graduation within courses offered to both majors and non-majors (Franklin, 2012). For example, statistics majors should know some theory behind regression, but non-majors may just need to be able to analyze software output. Therefore, the program has difficulties combining these two different 'needs' in a single course.

The next full review for the department will occur in 2019-2020. Chapter 4 of this report describes the development of the assessment plan that will be used for this review.

CHAPTER 4

CURRENT PROCESS

Upon starting this project, the author of this paper attended two UGA sponsored workshops on writing outcomes and deciding on assessment procedures (Gordon, 2013a and 2013b). The workshops discussed the basic theory behind learning outcomes and program assessment. The first workshop allowed department representatives to practice rewriting existing learning outcomes and receive feedback from colleagues in other departments. The second workshop exposed attendees to assessment types and methods that were being successfully utilized by other programs on UGA's campus. The information obtained during these workshops jumpstarted the assessment process within the statistics department.

Within the Department of Statistics at UGA, a Learning Outcome Assessment (LOA) Committee was created to discuss changes to current outcomes at the three program levels (Bachelor, Master, and Ph.D.). The committee consists of five faculty members: the Associate Department Head, Graduate Advisor, Graduate Director of Admissions, Undergraduate Coordinator, and an Assistant Professor active in Statistics Education research. The goal of this committee is to reestablish the learning outcomes and assessment plan for the Statistics Department at UGA. As discussed in Section 2.1, the first step in program assessment is to develop the student learning outcomes. Prior to the actions discussed in this report, the undergraduate learning outcomes were the same as those outlined by the ASA. In the first meeting of this committee, four broad learning areas were established and motivated by the ASA

Curriculum Guidelines (ASA, 2000). The department chose to focus the learning outcomes in four core areas: theory, data analysis, computing, and communication.

The second meeting of the committee brought discussion of the objectives within the four core areas. Individual members provided a written description of each of the core areas based on their typical teaching focus. The committee discussed the purpose of creating the outcomes and how they could possibly be assessed. They also began working on a curriculum map for each of the three program levels in relation to the four core areas. A smaller breakout group met later that month to edit the document and add further details to the curriculum map. This small group utilized the ASA guidelines and learning outcomes from similar statistics programs as inspiration. This group also decided it was best to build the learning objectives in cumulative levels throughout the bachelor, masters, and Ph.D. program. The following statement is included at the top of the objectives to explain this progression:

> The first column states the ASA expectations for the element of training. The subsequent columns elaborate on the details of that training, building in an inclusive way from the B.S. level, to the M.S. level, to the Ph.D. level (that is, B.S. level knowledge is also expected of M.S. students; B.S. and M.S. level knowledge are also expected of Ph.D. students). These levels (degrees) are based on experience.

The format of student learning outcomes was discussed in Section 2.2 of this document. The outcomes were written in such a way as to help instructors, professors, and graduate teaching assistants match their course materials to the department's overall plan. The learning outcomes then went through a series of critiques and rewrites before they were presented to the full faculty. Critiques brought about by committee members included discussions of specific items in each learning area as well as how classes fit into the curriculum map. The outcomes were also edited to change terms such as “understand” and “know” to action verbs (see Table 2). For example, in the computing core area a statement originally read, "Students should also use technology to visualize concepts and *understand* abstract ideas through simulations." The word *understand* was changed to the action verb, *illustrate* to create a measurable student learning outcome. Once the LOA committee was satisfied with the learning outcomes, they were presented to the department at the January 2014 faculty meeting. Overall, the learning outcomes were well received by the faculty and started a productive conversation. The initial skepticism by faculty about the LOA process was greatly diminished when committee members explained the purpose of program assessment. The main issues for faculty stemmed from the confusion between course assessment that is commonly used by faculty, and programmatic assessment. Members of the LOA committee explained that program assessment is meant to evaluate programs as a whole and not individual instructors, classes, or students. Faculty members made interesting observations on the outcomes and curriculum maps. One member said that in the past he had focused on teaching a lot of technical material rather than working on communication skills through papers, group work, or presentations. Other faculty agreed, saying that they could do a better job of incorporating communications into their courses. Faculty who had additional concerns or contributions were asked to send them to the LOA committee.

The discussion of learning outcomes and curriculum mapping led to a brief discussion of the future of programmatic assessment in the department. Faculty members were concerned about the university guidelines and restrictions with respect to assessment. In designing the assessment plan, it is important that the plan be something that is manageable and informative the department, so the university criteria will be used as loose, rather than rigid, guidelines. Attendees of the faculty meeting also showed interest in developing rubrics for presentations and papers throughout the three program levels. Rubrics can be incorporated in capstone posters, capstone presentations, and graduate level requirements such as the qualifying exams, theses, dissertations, and proposals. Lastly, a professor pointed out that within our courses, topics covered and teaching methods should evolve based on the outcomes and new data received from assessment. This is a very key item and it emphasizes that programmatic assessment is an iterative process meant to improve student learning.

After much revision and discussion, the faculty approved the revised outcomes during the Spring 2014 semester. The finalized learning outcomes for the undergraduate program are included in Table 13.

The learning outcomes committee also worked to develop a curriculum map based on the four core areas. The goal of the map was to ensure the alignment of the curriculum and undergraduate student learning outcomes. Additional information on the purpose and uses of curriculum maps is included in Section 2.3. The curriculum map for the undergraduate program is included as Table 14. Several additions were made to the undergraduate curriculum map, including additional electives, the calculus sequence, and the computer science course. According to Table 14, the undergraduate program seems to be addressing each of the student learning outcomes at some point in the curriculum. The communication core area, however, could include more courses to introduce the necessary skills prior to their assessment during the capstone sequence (5010 – 5020). The communications area is also not addressed at all in any of the elective courses. The student learning outcomes associated with communications may need to be investigated further during the later stages of the assessment process. Overall, the curriculum map suggests that the capstone course will be the primary focus during assessment of the learning outcomes.

Table 13. Undergraduate Student Learning Outcomes

Core Area	Outcomes
Data Analysis	Students should be able to: obtain and use real data to answer a question requiring data; describe the different types of study designs (survey, experimental, observational), the role of randomization, and common sources of bias; interpret graphical displays and numerical summaries of data; explain that variability in data is natural, predictable and quantifiable; and make use of statistical inference. Students should be able to distinguish distribution types (population, sample or data, and sampling) and explain conceptually the role of a distribution and, statistical significance (including P-value and significance level), and margin of error and confidence level with intervals. Students should be able to interpret statistical results in the context of the original question. Students are expected to critique statistical information and develop a healthy skepticism about how statistics is used in practice.
Theory	Students should be able to explain the basic statistical theory underlying much of formal statistical estimation and inference. They should be able to justify theoretically the properties of the most commonly used frameworks for statistical estimation, inference and modeling. They should be able to apply the properties and criteria that can be used, in general, to derive, evaluate and compare statistical methods on theoretical grounds.
Computing	Students should be able to use technology to analyze data, with students focusing on the interpretation of results and the checking of conditions for inference. Students should also use technology to visualize concepts and illustrate abstract ideas through simulations. Students should become proficient using statistical packages such as Minitab, SAS, and R and working with spreadsheets and using web-based resources. Students should use technology to work with large, real and sometimes messy data sets.
Communication	Students should be able to effectively use the language of statistics to communicate ideas verbally and in writing. Students working in groups should be able to successfully collaborate with researchers when a more senior statistician is present. Students should be able to explain basic statistical concepts, methods and results in language that is clear to non-statisticians and relevant to applied problems.

Table 14. Undergraduate Curriculum Map

Required Courses	Learning Outcomes			
	L1 (DATA)	L2 (THEORY)	L3 (COMPUTING)	L4 (COMM.)
CSCI 1301			I, D	
2000	I			
MATH 2250		I, D		
MATH 2260		I, D		
MATH 2270		I, D		
MATH 3300 or 3000		I		
4210	I, D		I	
4220	I, D		I	
4230	I, D		I	
4360			I, D, A	
4510 – 4520		I, D, A		
5010 – 5020	D, A		I, D, A	I, D, A

Elective Courses	Learning Outcomes			
	L1 (DATA)	L2 (THEORY)	L3 (COMPUTING)	L4 (COMM.)
4100		I, D		
4240	I, D		I	
4260	I, D		I	
4280	I, D		I	
4290	I, D		I	
4360			I, D, A	
4380	I, D		I	
4630 – 4640	I, D		I	

As of publication, the department has completed the first step of the program assessment cycle. They have articulated and agreed on student learning outcomes that are clear, measurable, and written in accordance with the theory discussed in Section 2.2. The department has also created a curriculum map to understand where the individual courses fit within the program. The next steps in the cycle are to identify assessment methods, collect data, and make changes based on this data. The future assessment plans for the Department of Statistics at UGA are included in Chapter 5.

CHAPTER 5

FUTURE DIRECTIONS

Programmatic assessment is a systematic process to improve student learning. It is often confused with typical classroom assessment used to assign grades to individual students. The data collected through program assessment focuses on groups of students as a whole and what can be done to improve the overall, rather than individual, student experience. The cyclic assessment process includes four key steps: establishing student learning outcomes, deciding on assessment methods, collecting and analyzing data, and reflecting on the data.

The Department of Statistics at UGA has successfully completed the first stage of the assessment cycle. We have agreed upon the knowledge, skills, and abilities that are expected from the graduates of the B.S. program. The student learning outcomes are separated into four core areas: data analysis, theory, computing, and communications. The process of creating these outcomes has prompted conversations about the curriculum, teaching methods, and goals for our students. The curriculum map created in Chapter 4 has allowed the committee to see possible areas for development within the program. For the undergraduate program, the learning outcome relating to communications provides the most room for improvement. The curriculum map will assist in future discussions of necessary changes to the undergraduate curriculum, for example with respect to developing communication and will assist in the creation of the assessment plan.

The next step in developing a new assessment plan is to understand how the current plan is functioning. The current plan, discussed in Section 3.3, utilizes many indirect methods to assess student learning. The LOA Committee should discuss the effectiveness of the current assessment plan and how they wish to assess in the future. To determine where to assess outcomes within the program, the committee can use the curriculum map discussed in Chapter 4. They also can use a newly created objectives-by-measures matrix to decide on methods, like the example discussed in Section 2.4.5. Methods that are valuable and feasible tools for our department would receive a check, while those without a check are not considered to be an effective tool for assessment. A blank objectives-by-measures matrix to be filled in by the committee is included in Table 13 of the Appendix. Table 3 in Section 2.4.2 provides additional assessment methods the department may want to consider in the assessment plan. The committee should ensure that there are multiple opportunities to assess each student learning outcome. They should also be mindful to include opportunities to triangulate the data by using multiple assessment types, for example, both direct and indirect measures. More detail is given about the value of triangulation in Section 2.4.5. Overall, the methods selected should be reasonable with respect to the effort required by faculty and provide informative data upon completion.

A completed and 'ideal' objectives-by-measures matrix for the undergraduate program is included in Table 15. This matrix is intended to provide recommendations to assist the faculty members in filling out their own matrix for the undergraduate and graduate level programs. It is not intended as a final version, nor is its inclusion in this document intended to circumvent the process of the committee in making decisions about how the department will assess the learning outcomes The plan is meant to be feasible and provide the most valuable assessment data with minimal time and effort. A full description of the advantages and disadvantages of assessment methods is included in Section 2.4.3. The ideal assessment plan included below, uses an alumni survey, exit interview, faculty discussion, records of student data, and a student focus group as the indirect assessment measures. An example alumni survey that could be used or adapted for our department's assessment plan is included in the Appendix. This survey was based on the UGA Department of Marketing and Distribution's alumni survey (Office of Academic Planning, 2012). It includes applications of the four core areas in the workforce, a comment section for program improvements, and questions on current employment status.

Table 15. Ideal Objectives-by-Measures Matrix

Possible Assessment Methods	Type	Data	Computing	Theory	Comm.
Alumni survey	I	✔	✔	✔	✔
Current student survey	I				
Employer survey	I				
Exit interviews	I	✔	✔	✔	✔
Faculty discussion	I	✔	✔	✔	✔
Records of student data	I	✔	✔	✔	✔
Student focus group	I	✔	✔	✔	✔
Syllabus analysis	I				
Capstone poster (with rubric)	D	✔	✔	✔	✔
Capstone presentation (with rubric)	D	✔	✔	✔	✔
Course paper (with rubric)	D				
Course presentation (with rubric)	D				
Objective test (4XXX final)	D	✔	✔	✔	
Portfolios (with rubric)	D				
Short embedded assignments	D				

The exit interviews used in the ideal assessment plan are a valuable and simple way to gather qualitative and quantitative information. These exit interviews would be a summative and indirect form of evidence, because they are perceptions of student learning at the end of the program. An example exit interview is included in the Appendix. The interview questions are very similar to the version used in the 2003 assessment plan, however, the working knowledge questions (#8) are grouped based on the four core learning areas. By using the undergraduate coordinator as the moderator of the exit interviews, unbiased data can be gathered since the students are comfortable sharing their thoughts with her.

Records of student data, faculty discussions, and focus groups are also included in the ideal matrix in Table 15. Records of student data would allow faculty to see any trends in student achievement and document progress over the years. These data would be updated during each academic year and include graduation rates, course enrollment, course grade averages, and student honors. An example document for the record of student data is included in the Appendix. The faculty discussion would help to synthesize the data collected and close the assessment loop. This discussion is like a focus group of the faculty members involved in the program. Lastly, focus groups of students could be used to gather qualitative and indirect data. The committee should also consider providing pizza or another similar incentive for students as a way to encourage participation in this add-on assessment method. The committee should be careful in choosing the faculty moderator and guiding questions to maximize collected the data using focus groups. A syllabus analysis, employer survey, or current student survey could also easily be incorporated into this ideal plan as another indirect assessment measure.

Based on the ideal objectives-by-measures matrix (Table 15) the direct assessment methods include objective tests in 4000 level courses and assignments graded with rubrics. The objective tests could include finals or midterms in key 4000 level courses like Mathematical Statistics I (STAT 4510). This would help the department to gather additional direct evidence in courses that were marked with an ‘A’ in the undergraduate curriculum map (Table 14).

Instructors of these courses would be responsible for reporting student's working knowledge in the related core learning area to the LOA Committee.

Previous faculty discussion has suggested the idea of adding rubrics to areas within the undergraduate program. These could be added to the capstone presentation or poster session, or to other regular course assignments that are also used in program assessment. As discussed in Section 2.4.4, the rubrics will serve as quantitative and direct assessment methods. The rubrics that are incorporated into the assessment plan should follow the theory from Section 2.4.4 and provide useful information about the program as a whole. During February 2014, a workshop by the TA Development Office at UGA provided some helpful suggestions on writing rubrics. This workshop provided the foundation of the rubrics that will be created for the department's updated assessment plan. The notes from this workshop as well as several example rubrics have been provided to the LOA Committee to assist in creating future rubrics. Two example rubrics for the capstone presentation and poster session are also included in the Appendix. The capstone presentation rubric is an analytic rubric based around the four core learning areas. Faculty members or other audience members who watch the presentations could complete this rubric for each group. The capstone poster rubric is also focused around the core areas, but functions more like a checklist. This rubric could be handed out and completed by the departmental poster session attendees. Both rubrics would aid in grading the capstone assignments and understanding student learning across the program. The example rubrics provided should serve as guidelines for the faculty in creating their own rubrics for program assessment.

The faculty committee has also been provided with a blank timetable (Table 18 in the Appendix) to assist in setting up the cycle of assessment. The timetable should be used after the assessment methods have been discussed and agreed upon. The committee should also determine who is responsible for each item contained in the table. For example, the capstone instructors may be responsible for collecting rubric data on presentations, but another person is needed to summarize this data. There should also be a point person who is responsible for submitting the UGA required reports. The timetable should be very helpful in keeping the assessment plan and reporting cycle on track during each academic year.

An ideal timetable using the methods previously discussed in the recommended assessment plan is included in Table 16 below. The timetable suggests scheduling a dedicated faculty discussion of assessment results during the annual Fall Retreat. This would help the assessment committee to close the loop and write the UGA required reports that are due on October 1st of each year. Also included during the fall semester are objective tests in 4000 level courses. Next, during the spring semester the department could use their capstone presentation rubrics and capstone poster rubrics. The exit interview could then be given at the very end of each academic year to the graduating seniors. A data review is also included on the timetable for each summer in the assessment cycle. The data review would include completing the record of student data as well as combining any assessment data that was collected during the previous academic year. This step completed in the summer semester, would prepare the data for the fall semester's faculty discussion and report writing. Additionally, focus interviews could be scheduled twice in the seven-year cycle. If the focus interviews are scheduled right before the writing of the two full reports, faculty members could gain additional insight from students before reporting to the UGA Program Review and Assessment Committee. Lastly, scheduling an alumni survey once every assessment cycle (i.e. every 7 years), could help the department to keep up with their recent graduates.

Table 16. Ideal Assessment Timetable

Fall Semester (beg.)	Fall Semester (end)	Spring Semester (beg.)	Spring Semester (end)	Summer
YEAR 1				
Faculty discussion	4510 Final	Capstone presentation rubric	Capstone poster rubric & exit interview	Data review
Brief Report Due Oct. 1st				
YEAR 2				
Faculty discussion	4000 level final	Capstone presentation rubric	Capstone poster rubric & exit interview	Data review
Brief Report Due Oct. 1st				
YEAR 3				
Focus group & faculty discussion	None	Capstone presentation rubric	Capstone poster rubric & exit interview	Data review
Full Report Due Oct. 1st				
YEAR 4				
Faculty discussion	4510 Final	Capstone presentation rubric	Capstone poster rubric & exit interview	**Alumni survey** & data review
Brief Report Due Oct. 1st				
YEAR 5				
Faculty discussion	4000 level final	Capstone presentation rubric	Capstone poster rubric & exit interview	Data review
Brief Report Due Oct. 1st				
YEAR 6				
Focus group & faculty discussion	None	Capstone presentation rubric	Capstone poster rubric & exit interview	Data review
Full Report Due Oct. 1st				
YEAR 7				
Review and discussion	Review and discussion	Review and discussion	Review and discussion	Review and discussion
Program Review				

The most important point to remember is the final step in the assessment cycle, closing the loop. The theory of this step was discussed previously in Section 2.4.6. After assessment data are collected on the learning outcomes, they must be used to make changes within the program. The decisions and adaptions made during this phase are dependent upon the data collected during the previous step. For example, the data could suggest that students can effectively analyze data, but are less successful at explaining their results to others. In this case, faculty members should discuss ways in which to improve communication skills within the program. These program changes could include course curriculum revisions, changes to the requirements for a major, or expansions to academic advising (Office of Institutional Assessment, n.d.). The loop of programmatic assessment is closed when programs have discussed the results and made changes to improve student learning.

Over the next seven years, the department will implement the assessment plan that they develop based on the UGA reporting cycle. While the assessment plan is still in development, this paper has started many valuable conversations in the department. Faculty members are interested in adapting their courses and finding new ways to help students master our learning outcomes. Program coordinators and instructors are also working to add rubrics to the curriculum. The hard work of the LOA committee will bring about many positive changes within the department. These changes brought about by programmatic assessment will undoubtedly improve student learning and create a stronger undergraduate statistics program at the University of Georgia.

REFERENCES

American Association for Higher Education. (1996). 9 principles of good practice for assessing student learning. Retrieved from http://www.academicprograms.calpoly.edu/pdfs/assess/nine_principles_good_practice.pdf

American Statistical Association. (2000). Curriculum guidelines for undergraduate programs in statistical science. Retrieved from http://www.amstat.org/education/curriculumguidelines.cfm

Bloom, Benjamin S. & David R. Krathwohl. (1956). *Taxonomy of educational objectives: The classification of educational goals, by a committee of college and university examiners.* Handbook 1: Cognitive domain. New York: Longmans.

Bryce, G. R., Gould, R., Notz, W. I., & Peck, R. L. (2000). Curriculum guidelines for bachelor of science degrees in statistical science. *Curriculum Guidelines for Undergraduate Programs in Statistical Science*. Retrieved from http://www.amstat.org/meetings/jsm/2000/usei/curriculum.PDF

Cal Poly Pomona. (2007). Department of mathematics and statistics assessment plan. Retrieved from http://www.csupomona.edu/~math/Documents/Homepage/DepartmentAssessmentPlan.pdf

Carr, J. W. & Hardin, S. (2010). The key to effective assessment: Writing measurable student learning outcomes. *Recreational Sports Journal,* 34, 138 – 144.

Clark, D. R. (1999). The three types of learning. *Bloom's Taxonomy of Learning Domains*. Retrieved from http://www.nwlink.com/~donclark/hrd/bloom.html

Department of Statistics. (n.d.). Statistics major. *Statistics: Franklin College*. Retrieved from http://www.stat.uga.edu/statistics-major

Franklin, C. (2003). Major assessment plan of the undergraduate statistics major. Unpublished manuscript. Department of Statistics, University of Georgia, Athens, GA.

Franklin, C. (2012). Full review of the undergraduate statistics major. Unpublished manuscript. Department of Statistics, University of Georgia, Athens, GA.

Groeneveld, R. A. & Stephenson, R. W. (1999). Outcomes assessment in the B.S. statistics program at Iowa State University. In B. Gold, S. Z. Keith, & W. A. Marion (Eds.), *Assessment practices in undergraduate mathematics* (pp. 49-53). USA: The Mathematical Association of America.

Gordon, L. (2013a). *Workshop: Writing student learning outcomes* [PowerPoint slides]. Retrieved from http://oap.uga.edu/uploads/assess/Outcomes_Workshop_Power_Point_-_9.20.13.pdf

Gordon, L. (2013b). *Workshop: Choosing assessment measures* [PowerPoint slides]. Retrieved from http://oap.uga.edu/uploads/assess/Assessment_Measures_Wkshp_2013_for_webpage.pdf

Goucher College. (n.d.). Purpose of student learning outcomes. *Student Learning Goals and Outcomes*. Retrieved from http://www.goucher.edu/academics/office-of-the-provost/student-learning-goals-and-outcomes/purpose-of-student-learning-outcomes

Hatfield, S. (2009). Idea paper #45: Assessing your program-level assessment plan. *The Idea Center*. Retrieved from http://www.theideacenter.org/sites/default/files/IDEA_Paper_45.pdf

Horton, N. J. (2013). Updating the guidelines for undergraduate programs in statistics [Webinar]. In *CAUSE Teaching and Learning Webinar Series*. Retrieved from https://www.causeweb.org/webinar/teaching/2013-11/

Jonson, J. (2006). Guidebook for programmatic assessment of student learning outcomes. *University-wide Assessment*. Retrieved from University of Nebraska Lincoln: http://www.unl.edu/svcaa/assessment/learningoutcomes_guidebook.pdf

Jordan, D., DeGraaf, D., & DeGraaf, K. (2005). *Programming for parks, recreation, and leisure services: A servant leadership approach*. 2nd ed. State College, PA: Venture Publishing

Lazar, N. A., Reeves, J., & Franklin, C. (2011). A capstone course for undergraduate statistics majors. *The American Statistician,* 65(3), 183-189.

Lindholm, J. A. (2009). Guidelines for developing and assessing student learning outcomes for undergraduate majors. *Learning Outcomes Assessment for Undergraduate Academic Programs,* (1st ed.). Retrieved from University of California, Los Angeles website: http://www.wasc.ucla.edu/eer_endnotes/Learning_Outcomes_Guidelines.pdf

Macalester College. (2012). The academic program. *College Catalog*. Retrieved from http://catalog.macalester.edu/content.php?catoid=4&navoid=619

Maki, P. (2010). *Assessing for learning* (2nd ed.). Sterling, VA: Stylus Publishing.

Middle States Commission on Higher Education. (2007). Student learning assessment: Options and resources (2nd ed.). Retrieved from http://www.msche.org/publications/SLA_Book_0808080728085320.pdf

Mullinix, B. B. (2009). Rubrics. *The TLT Group*. Retrieved from http://tltgroup.org/resources/Rubrics.htm

Office of Academic Planning. (n.d.). Student learning outcomes assessment. Retrieved from http://oap.uga.edu/assessment/sloa/

Office of Academic Planning. (2012). Department of marketing and distribution: Undergraduate major assessment plan. Retrieved from http://oap.uga.edu/assessment/plan/

Office of Assessment. (2014). Program assessment plans: Department of mathematics. Retrieved from University of Rochester: Arts, Sciences, and Engineering: http://www.rochester.edu/college/ assessment/assets/pdf/undergraduate/LearningObjectives-MTH-v2.pdf

Office of Experiential Learning. (n.d.). Writing SMART learning objectives. Retrieved from University of Central Florida: http://explearning.ucf.edu/registered-students/tips-for-success/writing-smart-learning-objectives/195

Office of Institutional Assessment. (n.d.). Assessment resources. Retrieved from Texas A&M University: http://assessment.tamu.edu/resources/resources_index.html

Palomba, C. & Banta T. (1999). *Assessment essentials: planning, implementing, and improving assessment in higher education*. San Francisco: Jossey-Bass.

Peck, R. & Chance, B. L. (2007). Assessment at the program level: Using assessment to improve undergraduate statistics programs. In L. Weldon & B. Phillips (Eds.), *Proceedings of the ISI/IASE Satellite on Assessing Student Learning in Statistics*. (pp. 1-6). Lisbon, Portugal.

Public Affairs Division. (2013). UGA by the numbers. *The University of Georgia*. Retrieved from http://www.uga.edu/images/uploads/2013UGA_ByNumbers.pdf

Quick, P. S. (2014). *It looks like an 'A' but I don't know why: How to construct and use rubrics for assessment and learning* [PowerPoint slides].

Ritter, M. A., Starbuck, R. R., and Hogg, R. V. (2001). Advice from prospective employers on training BS statisticians. *The American Statistician*, 55, 14.

Stassen, M., Doherty, K, & Poe, M. (2001). Program-based review and assessment: Tools and techniques for program improvement. Retrieved from Office of Academic Planning & Assessment, University of Massachusetts Amherst: http://www.umass.edu/oapa/oapa/publications/online_handbooks/program_based.pdf

Stevens, D. D. & Levi A. J. (2005). *Introduction to rubrics*. (pp. 82). Sterling, VA: Stylus.

Stufken, J. & Taylor, R. L. (2013) A brief history of the department of statistics. In A. Agresti & X. Meng (Eds.), *Strength in numbers: The rising of academic statistics departments in the U.S*. (pp. 381-393). New York: Springer.

Suskie, L. (2009). *Assessing student learning: A common sense guide (*2nd ed.). San Francisco: Jossey-Bass.

The University of Rhode Island. (2012). Designing a meaningful curriculum map: Reflecting on the level of learning expected. *Student Learning, Outcomes Assessment and Accreditation*. Retrieved from http://web.uri.edu/assessment/files/Understanding_IRE_2012.pdf

Schuh, J. H. & Upcraft, M. L. (2001). *Assessment practice in student affairs: An applications manual*. San Francisco: Jossey-Bass Publishers.

Washington State University. (2009). Validity, reliability, and triangulation in program assessment. *Center for Teaching, Learning, and Technology*. Retrieved from http://ai.vancouver.wsu.edu/~nwdcsd/wiki/images/9/9c/Validity,_Reliability,_and_Triangulation_in_Program_Assessment_Spring09.pdf

APPENDIX

Table 17. Objectives-by-Measures Matrix for Future Use

Possible Assessment Methods	Type	Data	Computing	Theory	Comm.
Alumni survey	I				
Current student survey	I				
Employer survey	I				
Exit interviews	I				
Faculty discussion	I				
Records of student data	I				
Student focus group	I				
Syllabus analysis	I				
Capstone poster (with rubric)	D				
Capstone presentation (with rubric)	D				
Course paper (with rubric)	D				
Course presentation (with rubric)	D				
Objective tests	D				
Portfolios (with rubric)	D				
Short embedded assignments	D				

Table 18. Assessment Timetable for Future Use

Fall Semester (beg.)	Fall Semester (end)	Spring Semester (beg.)	Spring Semester (end)	Summer
YEAR 1				
Brief Report Due Oct. 1st				
YEAR 2				
Brief Report Due Oct. 1st				
YEAR 3				
Full Report Due Oct. 1st				
YEAR 4				
Brief Report Due Oct. 1st				
YEAR 5				
Brief Report Due Oct. 1st				
YEAR 6				
Full Report Due Oct. 1st				
YEAR 7				
Program Review				

Note: Adapted from Stassen et al. (2001)

Example Alumni Survey

1) What year did you graduate from the statistics department?

- ☐ 20XX
- ☐ 20XX
- ☐ 20XX
- ☐ 20XX
- ☐ 20XX
- ☐ 20XX
- ☐ 20XX or earlier

2) Indicate the degree to which the statistics bachelor's program prepared you for your current position with regards to the following topics.

	1 – strongly disagree	2 – disagree	3 – neutral	4 – agree	5 – strongly disagree
Interpreting statistical results in context	1	2	3	4	5
Develop a skepticism about statistics in practice	1	2	3	4	5
Illustrate abstract ideas through simulations	1	2	3	4	5
Use statistical packages such as SAS, R, or Minitab	1	2	3	4	5
Compare statistical methods on theoretical grounds	1	2	3	4	5
Explain theory underlying formal statistical inference	1	2	3	4	5
Explain basic statistical concepts to non-statisticians	1	2	3	4	5
Communicate statistical ideas verbally and in writing	1	2	3	4	5

3) Indicate your level of satisfaction with the statistics department at UGA.

	1 – strongly disagree	2 – disagree	3 – neutral	4 – agree	5 – strongly disagree
I am very satisfied with my experience as a statistics major at UGA	1	2	3	4	5
If I had to do it again, I would major in statistics at UGA.	1	2	3	4	5
I would recommend the statistics major to friends, family, and colleagues.	1	2	3	4	5

4) Indicate the usefulness of each course in preparing you for your current position.

	Did not take	1 – strongly disagree	2 – disagree	3 – neutral	4 – agree	5 – strongly disagree
STAT 4210 (Statistical Methods)	-	1	2	3	4	5
STAT 4220 (Applied Experimental Design)	-	1	2	3	4	5
STAT 4230 (Applied Regression Analysis)	-	1	2	3	4	5
STAT 4360 (Statistical Software Programming)	-	1	2	3	4	5
STAT 4510-4520 (Mathematical Statistics)	-	1	2	3	4	5
STAT 5010-5020 (Capstone Course)	-	1	2	3	4	5

5) What was the most valuable statistics course that you had at UGA?

6) What is the biggest thing that the statistics department could do to improve the program?

7) Indicate the company name, job title, and location of your first position after graduating from the department. If you attended graduate school, please state the name of the school and program.

8) Indicate your annual salary at your first job after graduating from the statistics department.

- ☐ Under $30,000
- ☐ $30,001 - $40,000
- ☐ $40,001 - $50,000
- ☐ $50,001 - $60,000
- ☐ $60,001 - $70,000
- ☐ $70,001 - $80,000
- ☐ $80,001 - $90,000
- ☐ Over $90,000

9) Indicate the company name, job title, and location of your current position. If you are currently in graduate school, please state the name of the school and program.

10) Indicate your annual salary at your current position.

- ☐ Under $30,000
- ☐ $30,001 - $40,000
- ☐ $40,001 - $50,000
- ☐ $50,001 - $60,000
- ☐ $60,001 - $70,000
- ☐ $70,001 - $80,000
- ☐ $80,001 - $90,000
- ☐ Over $90,000

Example Exit Interview

1) What was the most valuable aspect of your experience as a statistics major at UGA?

2) What was the least valuable aspect of your experience as a statistics major at UGA?

3) Is there one course you took that you feel should definitely be removed from the major? Explain.

4) Is there one course you took that you feel should definitely not be removed from the major? Explain.

5) Please describe any suggestions you have for improving the academic experience for future statistics majors at UGA. This could include any content areas you wish you had learned more about, any opportunities you wish you had been available, any other skills you wish could have better developed, or any other interactions or issues.

6) What statistical software packages and data management skills have you acquired while at UGA?

7) What area of application did you focus on outside of statistics? How would you describe your background in this area?

8) In your opinion, rate the level of your working knowledge in the following areas:

	1 – very weak	2 – weak	3 – adequate	4 – strong	5 – very strong
Design of studies and surveys	1	2	3	4	5
Formal statistical inference	1	2	3	4	5
Interpretation of statistical results	1	2	3	4	5
Role of randomization	1	2	3	4	5
Theory of statistical estimation	1	2	3	4	5
Justify modeling properties	1	2	3	4	5
Theory of statistical inference	1	2	3	4	5
Compare methods on theoretically	1	2	3	4	5
Use technology to analyze data	1	2	3	4	5
Illustrate ideas through simulations	1	2	3	4	5
Statistical packages (SAS, R, etc.)	1	2	3	4	5
Working with large, messy data sets	1	2	3	4	5
Oral communication of statistics	1	2	3	4	5
Written communication of statistics	1	2	3	4	5
Group collaborations	1	2	3	4	5
Explaining basic statistical concepts	1	2	3	4	5

9) What are you current plants after graduation?

- ☐ Graduate school (in statistics) — Please elaborate:
- ☐ Graduate school (in another discipline)
- ☐ Industry
- ☐ Government
- ☐ Other
- ☐ Undecided

10) Is there anything we did not ask you on this survey that you want to share or are there any other comments you have on this survey instrument?

Example Record of Student Data

Academic Year:		
Estimated Number of Majors:		
# of Graduates (Fall):	# of Graduates (Spring):	# of Graduates (Summer):
Student Honors and Awards:		
Graduate School Placement Rate:		
Job Placement Rate:		
Additional Comments:		

Fall		
Course	#	GPA
4210		
4220		
4230		
4240		
4280		
4510		
4630		
5010		

Spring		
Course	#	GPA
4100		
4210		
4220		
4230		
4260		
4290		
4360		
4380		
4520		
4640		
5020		

Summer		
Course	#	GPA
4210		
4230		
4360		

Example Capstone Presentation Rubric

Group: ______________________________ Reviewer: ______________________________

______________________________ Topic: ______________________________

______________________________ Date: ____________

Core Areas	Exceeds Expectations	Meets Expectations	Does Not Meet Expectations
DATA ANALYSIS	□ Interprets all graphical displays or numerical summaries	□ Interprets most graphical displays or numerical summaries	□ Does not interpret graphical displays or numerical summaries
	□ Completely discusses role of randomization or source of bias	□ Mentions role of randomization or source of bias	□ Fails to mention role of randomization or source of bias
	□ Clearly explains statistical significance, margin of error, or confidence intervals	□ Explains statistical significance, margin of error, or confidence intervals, but not clearly	□ Minimal to no explanation of statistical significance, margin of error, or confidence intervals
COMPUTING	□ Demonstrates advanced knowledge of SAS, R, or similar package	□ Demonstrates working knowledge of SAS, R, or similar package	□ Demonstrates minimal knowledge of SAS, R, or similar package
	□ Successfully deals with large or messy data sets	□ Deals with large or messy data sets with minimal errors	□ Deals with large or messy data sets in unsatisfactory manor
	□ Use software to check all conditions for inference	□ Use software to check some conditions for inference	□ Fails to use software to check conditions for inference
THEORY	□ Justifies theoretically the basic properties of inference or modeling	□ Briefly discusses a theoretical aspect of inference or modeling	□ Fails to justify theoretical properties of inference or modeling
	□ Clearly explains basic theory underlying formal estimation	□ Explains basic theory underlying formal estimation	□ Does not explain basic theory underlying formal estimation
	□ Fully compares statistical methods on theoretical grounds	□ Mentions some theoretical attributes of statistical methods	□ Fails to discuss theoretical attributes of statistical methods
COMM.	□ Professional presentation	□ Clear presentation	□ Poor presentation
	□ Strong group collaboration with seamless work division	□ Group collaboration is present, but work possibly divided	□ Minimal group collaboration and work was clearly divided
	□ Successfully explains statistical results in context	□ Explains statistical results, but not in context	□ Fails to explain statistical results and does not address context
Comments:			

Example Capstone Poster Rubric

Topic: ____________________________________

Place a check with description that matches student work.

	YES	NO
DATA ANALYSIS		
Correctly interprets graphical displays or numerical summaries of data		
Successfully interprets statistical results in context of research question		
Discusses role of randomization or common sources of bias		
COMPUTING		
Uses technology to analyze data or to visualize concepts		
Demonstrates knowledge of statistical packages such as SAS, R, or Minitab		
Shows ability to deal with large or messy data sets		
THEORY		
Explains basic theory underlying formal statistical estimation		
Justifies theoretically the basic properties of inference or modeling		
Compares statistical methods on theoretical grounds		
COMMUNICATION		
Shows evidence of strong group collaboration		
Successfully explains basic statistical concepts		
Poster is visually pleasing and gives overview of project		
Please include any comments on back of this checklist		