5-2017

Inclusive Teaching Strategies: An Evaluation of Course Structure and Summative Assessment in Introductory Biology

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A thesis

presented to

the faculty of the Department of Biological Sciences

East Tennessee State University

In partial fulfillment

of the requirements for the degree

Master of Science in Biology

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by

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May 2017

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Keywords: Summative assessment, Bloom's Taxonomy, first generation students, active learning, course structure, faculty survey, introductory biology.

ABSTRACT

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Several active learning strategies have been used when increasing the structure of a course as increasing course structure has been known to improve student learning in introductory STEM courses. Much has been studied on the value of frequent formative assessment; however, few studies have evaluated the effective modes of delivering summative assessment. This study examines the use of summative assessment as an inclusive teaching practice to improve first generation college student success in introductory biology and also uses faculty surveys to find out how instructors structure their introductory biology course and why they are structured that way. Final exams were evaluated by Bloom's Taxonomy of Learning. Survey results showed that many instructors used online activities most of the time to supplement face-to-face courses. However, student and faculty viewpoints on assessments offer many interesting insights into how instructors may modify teaching strategies to increase the success of diverse student populations.

DEDICATION

I dedicate this work to God Almighty, the One in whom I live, move, and have my being. I am nonexistent without you Lord. I also dedicate it to my late father, Mr. D. G. Agboola. Thank you for bringing me up in the way of the Lord. I can never forget you.

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Dr. Hiatt for, her relentless effort in making me a better student, teacher, and writer. To members of my committee, Dr. Brown and Dr. McIntosh, thank you for your constructive criticisms and feedback. I cannot forget the immense contribution of David Ford. Knowing you is a blessing indeed.

To my crown, Dr. A. Adelaja, you have brought me nothing but joy. You have supported me in every possible way a husband can. I love you dearly.

To the best mother on earth, Mrs. E. F. Agboola and best siblings ever, Segun, Damilare, and Titilayo, my world is incomplete without you.

I am sincerely grateful to Mrs. S. F. Korode and family, Mr. S. O. Korode and family, Mr. Ajirotutu and family, Mr. Adeboye and family, and all my friends whose names I may not be able to mention.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

In Science, Technology, Engineering, and Mathematics (STEM) and other courses, instructors use various approaches to create a learning environment that makes students of various backgrounds feel they are of the same value as other students. These approaches are known as inclusive teaching strategies. These strategies enable instructors to identify and provide solutions to tensions that might occur in the classroom (Ambrose et al*.* 2010). Common inclusive teaching strategies include group projects, anonymous feedback, quizzes, game-based learning, use of clickers, mid-semester feedback, formative and summative assessments, and end of semester surveys. These strategies are important in making students see the classroom as a community that is accommodating.

Course Structure

Course structure can be defined as the arrangement of activities before, during, and after teaching the topics in any course to support the learning objectives. The structure of a course is simply what makes up the course in terms of teaching and learning. Instructional design, also known as instructional systems design, can be used in effective course structure. Different instructional design models have been created but many of the models are based on the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model; a model developed by Florida State University to explain "the processes involved in the formulation of an instructional systems development (ISD) program for military interservice training that will adequately train individuals to do a particular job and which can also be applied to any interservice curriculum development activity." (Branson et al. 1975). This is because the model serves as a flexible guideline that can be easily applied to general education and training development (Occupational Safety and Health Administration, 2010). Course structure has been identified as one of the major factors that greatly influences student learning (Ames, 1992; Eom et al. 2006), hence it requires special attention.

First Generation Students

First-generation (FG) students are students that are the first in their families to attend college, or students that have neither parent(s) nor guardian with a four-year college degree (Bush, 2007). They are a special group of students, as they represent a sizeable minority in postsecondary education (Chen and Carroll, 2005; Mangan, 2015). The National Center for Education Statistics (NCES) defined FG students as undergraduates whose parents never enrolled in postsecondary education and showed that more than one-third of all current K-12 students in United States have parents who have not attended college The occurrence of FG students is highest among underrepresented minorities (Livingston, 2008; Aud et al. 2012).

Assessment

Assessment is a process of collecting and interpreting evidence of student progress to inform reasoned judgments about what a student or group of students knows relative to the identified learning goals (National Research Council, 2000). Angelo (1996) describes assessment in more depth by dividing it into four complementary components: use multiple methods; use multiple assessors; assess over time; and assess multiple dimensions of learning. Each of these four components has its own basis in assessment literature.

Balanced classroom assessment systems are formative and summative assessments (Fang and Wei, 2010). Much has been written using data gathered through formative assessment (focusing on classroom assessment technique) (Decristan et al. 2015; Glover et al. 2016; Palm et al. 2016), however, few studies have used summative assessments (Harlen, 2005; Joughin, 2010). Class assessment can both measure and promote higher-order cognitive skills (Brookhart, 2010; King et al. 2010). Summative assessments (which include questionnaires, surveys, interviews and final projects) can provide information on an intervention's efficacy and the worth, or value, of an intervention at its conclusion. Summative assessments are generally evaluative, rather than diagnostic, but some can be used diagnostically: using data available online through grading systems and databases, teachers can access assessment results from previous years or other courses. By reviewing assessment data, teachers may be able to identify students who are struggling academically in certain subject areas or concepts. Summative assessments are used for high-stakes purposes and have in recent decades become components of larger school-improvement efforts (Abbott et al. 2014). Summative assessments can verify students' understanding of the material they learn and provide objective criteria to assign grades; while formative assessments can gauge the effectiveness of teaching and contribute to a student's metacognition (Shepard, 2000; Aviles, 2001; Taras, 2005). Theoretically, practice and feedback provided by formative assessments manifest in higher summative assessment scores (Angelo, 1995).

Bloom's Taxonomy

Bloom's taxonomy of learning is an important tool used to conceptualize differences among types of cognitive tasks often found in assessments and learning objectives. The revised version by Krathwohl and his colleagues (2002) is used to rate the cognitive level of learning of all learning objectives and assessment items on a scale from one to six (1 = remembering, 2 = understanding, 3 = applying, 4 = analyzing, 5 = evaluating, 6 = creating). Scales 1 and 2 represent lower-order cognitive levels while higher-order cognitive levels are from scale 3 upward (Bloom, 1956; Krathwohl, 2002; Crowe et al. 2008; Momsen et al. 2013).

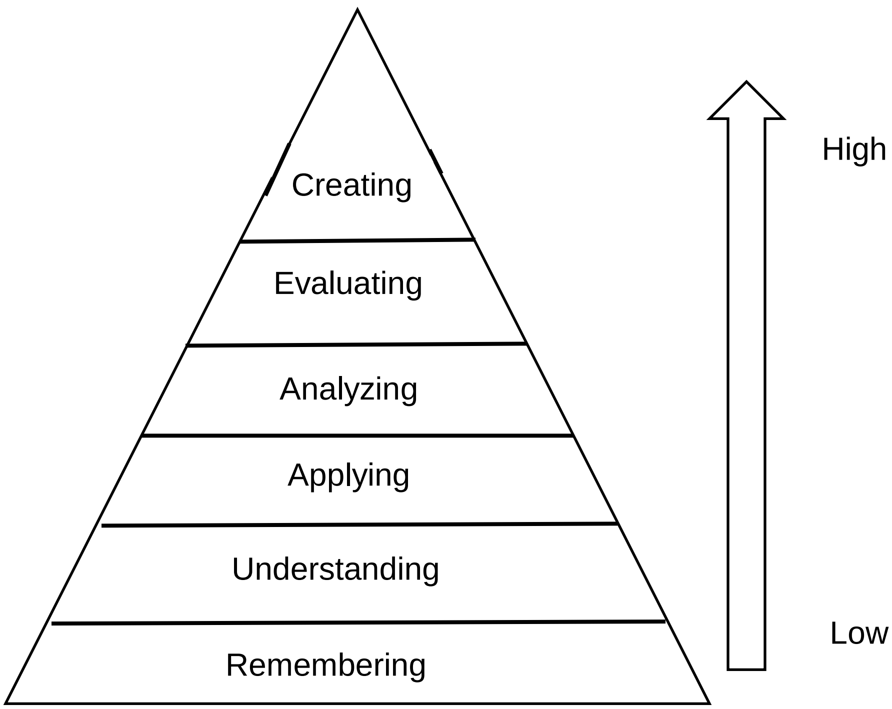

Figure 1.1 Revised version of Bloom's Taxonomy of learning (Adapted from Anderson and Krathwohl, 2001; Krathwohl, 2002).

Literature Review

FG students “often lack important ‘college knowledge’ about the process of preparing, applying, and paying for college due to the lack of experience with postsecondary education in their families” (Hossler et al. 1999). They have a tendency to report lower educational expectations, be less prepared academically, and receive less support from their families in planning and preparing for college than their peers whose parents attended college. FG graduates attain career positions and incomes almost identical to continuing generation (CG) graduates (those with at least one parent with a four-year college degree), because a bachelor’s degree levels the playing field after college for FG students and grants these new graduates an array of opportunities (Choy, 2001).

FG students are disproportionately overrepresented among most disadvantaged groups, being more likely to delay college entry, need remedial coursework, and drop out of college (Balemian and Feng, 2013). While students whose parents have a college education tend to experience ‘college as a continuation’ of their academic and social experiences in high school, going to college often constitutes a ‘disjunction’ in the lives of FG students and their families (Engle, 2007). Compared to their non-FG counterparts, some FG students may have more trouble prioritizing their time, as they often have to divide time between jobs and their schoolwork, so they cannot always put their academics first (Collier and Morgan, 2008).

It is well-described that active learning increases performance in introductory biology (Freeman et al. 2007). Additionally, intensive active learning, combined with frequent formative assessment, can lower failure rates in an introductory biology course for majors according to a study which concluded that failure rates were reduced by a factor of three (from 18.2 to 6.3%) with increased course structure (Freeman et al., 2011). In a recent study (the first of its kind) to bridge the gap between FG and CG students through an already known technique, using values affirmation (VA) interventions (a technique developed by Steele and Liu (1983) to promote self-integrity and self-worth through writing core values), results show improved overall semester GPA for FG students. Although the study was unable to distinguish between stereotype threat and cultural mismatch mechanisms or, more critically, measure variables that might have mediated the effects of the VA intervention for FG students, it was concluded that intervention can be effectively administered on a large scale without losing the potency of the intervention (Harackiewicz et al. 2014).

There was a disproportionate increase in FG student performance in a study analyzing the effectiveness of increased course structure across different student populations to the point of closing the achievement gap between FG and CG students (Eddy and Hogan, 2014). The study also found that black and FG students responded most strongly to the increased course structure. It was suggested in the study that instructors adapt teaching methods to accommodate diverse students (Eddy and Hogan, 2014).

Black and Wiliam (1998) state that a major limitation of using summative assessment to evaluate students' proficiency as it limits feedback for improvement. One solution to this limitation was provided by Stiggins (2001), who recommended that teachers keep the perspective that the real users of assessment data are the students themselves. It was found that formative assessments make students exceptionally good at regurgitating information on exams (as it requires students to respond to lower levels of cognitive thinking), and gradually reduce written and analytical skills (O'Neill et al. 2010). Unlike assessments that are formative or diagnostic, the purpose of a summative assessment is to determine the student's overall achievement in a specific area of learning at a particular time—a purpose that distinguishes it from all other forms of assessment (Black et al. 2004). Still, teachers' summative assessment practices have the potential to positively influence students and teachers. The influence of high-stakes test scores may even prompt some teachers to make significant changes to their continuous assessment practices. When teachers collaborate with each other and are coached by those with expertise in summative assessment practices, they are more likely to recognize the realities of their assessment competencies and begin to address their assessment needs (McMillan 2003, 2005, 2012), and do so without the negative effects associated with external tests and examinations, producing more comprehensive pictures of student achievement (Martínez et al. 2009).

Reports indicate that assessment items in introductory STEM courses tend to focus on lower-order cognitive skills (e.g., knowledge, comprehension, and less frequently application) and rarely, if ever, test higher-order cognitive skills (O'Neill et al. 2010; Momsen et al. 2013). A recent study indicates that the prevalence of lower Bloom level assessments can hamper students' critical thinking, while assessments at higher Bloom levels can increase students' critical thinking (Jensen et al. 2014). According to the study, assessments should aim at testing scientific skills, which are usually at higher Bloom levels; this makes students put extra efforts in learning the desired skills (Jensen et al. 2014). This can also result in thorough understanding of concepts (Lawson et al. 2000).

Statement of the Problem

In a study to analyze the effectiveness of increased course structure across different student population in an Introductory Biology class, there was a disproportionate increase in FG student performance, especially among underrepresented minorities, that closed the achievement gap between FG and CG students (Eddy and Hogan, 2014). The study identifies a need to further investigate the response of FG students to specific active learning interventions (Eddy and Hogan, 2014). Given that assessment strategies can heavily influence the ability of students to tackle higher-order questions, it would be valuable to investigate how summative assessment strategies may influence FG student outcomes in an introductory biology course. More and more faculty are utilizing online, supplemental materials in their traditional face-to-face courses and creating hybridized or “flipped” learning environments to improve student learning (McLaughlin et al. 2014). It is unclear how this teaching strategy may be impacting FG students. Therefore, when hybridizing and/or increasing the structure of a course, it would be important to know how the mode of delivery of summative assessments may affect at-risk groups of students like underrepresented groups and first generation college students.

Objectives

The study investigates how the delivery of frequent summative assessment, as an inclusive teaching practice, impacts student learning in a large enrollment introductory biology course that utilizes frequent active learning strategies in the classroom. The purpose of this study is to:

- observe the effect(s) of the mode of delivery of summative assessment on FG students in an introductory biology course.
- compare the effect(s) of the mode of delivery of summative assessment on FG students to their non-FG counterparts in an introductory biology course.

Hypotheses

1. Modes of frequent summative assessment delivery will increase FG students' academic performance.
2. FG students will have lower final grades across the three different modes of summative delivery compared to their non-FG counterparts.

This research is divided into two parts: The first part studies the effects of frequent summative assessment delivery on FG students in an introductory biology course while the second part emanates from the result of the first study and focuses on how different introductory biology courses are structured across southeastern universities in the US.

CHAPTER 2

THEORETICAL FRAMEWORK

Social science research is usually based on theoretical frameworks like post-positivism, critical theory, interpretivism, constructivism, grounded theory and so on (Mackenzie and Knipe, 2006). According to Maxwell (2012), theoretical framework in qualitative research is important in identifying how one's research is related to and contributes to existing theory and research. The framework for the first part of this research is constructivism while the second part is based on grounded theory.

Post-Positivism

Post-positivism arose from strong critiques of positivism. Positivism is a framework that claims that natural and human science share common logical and methodological principles, dealing with facts and not with values (Goede et al. 2011). Positivists attached reality to what is available to the senses (that is, what can be seen, heard, touched, etc.) and believed that inquiry should be based on scientific observation instead of philosophical speculation (Eriksson and Kovalainen, 2015). Positivists believed in the idea that observation and measurement was the core of science (empiricism). Post-positivism can be considered as an alternative form of positivism as it represents a wholesale rejection of the central beliefs of positivism. It is a research framework focused on learning universal truths about the human world. The justification for this practice is to find and teach universals. Post-positivists assert that if they work hard enough and do "good" research, they will approach the truth. Where the positivist believed that the goal of science was to uncover the truth, post-positivists hold that we can only approximate the truth, never explaining it perfectly. Post-positivism recognizes that all observation is fallible and has error and that all theory is revisable. Post-positivist research can be in the form of scientific tests for the effectiveness of a teaching program like large-scale assessment studies. The research designs in post-positivism are usually characterized by experiments, large-scale surveys, and sampling strategies. A research of this type is aimed at making a significant contribution to educators (Hacking, 1983; Heinecke et al. 2001; Creswell, 2012; Gray, 2013).

For example, if a research was titled "The Use of Summative Assessment to Improve First Generation Student Success in Introductory Biology" and approached from a post-positivist perspective alone, the research design would have been mapped out way ahead of time because it must be strictly adhered to throughout the research process. Involvement with participants in the research would be minimal to prevent methodical bias and comparisons between colleges that more recently adopted summative assessment might be compared to those that have been using it for a while. Whether or not summative assessment bridges the gap between FG students and CG students could also be considered as a post-positivist approach would focus more on summative assessment alone than the role of the first generation student (Feuer et al. 2002; Treagust et al. 2014).

Constructivism

Constructivism is a student-centered learning theory that views learning as an active process where learners construct new ideas based on their current or past knowledge (Bruner 1986, 1990, 1996). It is qualitative in nature. Constructivist-guided research aim at creating understanding to guide and inform practice. Rodger Bybee, the chief developer of the constructivist plan, came up with five (5) instructional phases (also known as the 5E model): Engage, Explore, Explain, Elaborate, Evaluate (Bybee, 1993). This plan has been very helpful in various forms of learning. The three important components of the constructivist model are group interaction, positive interdependence, and individual accountability (Kiraly, 2014). It can be referred to as interpretivism when it concerns philosophy of science but it is usually called constructivism when theories of learning and instructional models are involved (Schutt, 2014). Constructivism rejects the view of human knowledge that reality exists external to the researcher and must be investigated through the rigorous process of scientific inquiry (positivism); it believes that truth and meaning do not exist in some external world, but are created by the subject's interactions with the world (Treagust et al. 2014).

According to constructivists, meaning is constructed and not discovered, so subjects construct their own meaning in different ways, even in relation to the same phenomenon. Constructivism is subjective in nature as the methodology used is collaborative and it is usually student-centered. Constructivists assert that all research is influenced and shaped by preexisting theories and worldviews of the researchers (Gray, 2013; Treagust et al. 2014). Constructivism is used as a theoretical framework of this research (Inclusive Teaching Strategies: An evaluation of course structure and summative assessment in Introductory Biology) because qualitative and descriptive factors that comprise FG student populations are being considered as factors that might influence their response to summative assessment delivery.

Interpretivism

Interpretivism is an approach to social science that opposes the positivism of natural science as it looks for 'culturally derived and historically situated interpretations of the social life-world’ (Crotty, 1998). According to interpretivist approach, it is important for the researcher to appreciate differences between people. Moreover, interpretivism studies usually focus on meaning and may employ multiple methods in order to reflect different aspects of the issue. In relation to epistemology (study of knowledge), interpretivism is closely linked to constructivism. It asserts that natural reality (and the laws of science) and social reality are different and therefore require different kinds of methods. While the natural sciences look for consistencies in the data in order to deduce ‘laws’, the social sciences often deal with the actions of the individual. Accordingly, “interpretive researchers assume that access to reality (given or socially constructed) is only through social constructions such as language, consciousness, shared meanings, and instruments.” According to interpretivists, people cannot be separated from their knowledge; therefore there is a clear connection between the researcher and research subject (Saunders et al. 2007; Gray, 2013; Myers, 2013).

Future directions of this research could be approached from an interpretivist’s perspective. The research design will involve survey questions focused on FG students; their lives both inside and outside the classroom will be studied in order to know them better. Inclusive teaching strategies used by instructors will be measured qualitatively. A lot of ethical issues could be considered using this approach due to familiarity with the participants. There will be a lot of investigations on FG student’ lives because the aim will be to tell a story about their lives and consider factors in their personal lives that could influence their academic lives (Treagust, 2014).

Critical Theory

Critical theorists believe that what are presented as 'facts' cannot be disentangled from ideology and the self-interest of dominant groups. They also assert that conventional research practices are implicated, even if unconsciously, in the reproduction of the systems of class, race and gender oppression (Gray, 2013).

A good example of such research challenges the inequality of the status quo and the commitment toward social change. The nature of knowledge is not entirely objective as the methodology employed is subjective inquiry. The researcher seeks to challenge and transform the society, and not necessarily expand the body of knowledge. Researchers are enlightened intellectuals and activists and there is room for bias (Treagust et al. 2014). Critical theorists usually accuse interpretivists of adopting an uncritical stance towards the culture they are exploring, whereas the task of researchers is to question the structures and values of the society. (Heinecke et al. 2001; Treagust et al. 2014).

Grounded Theory

The theoretical framework primarily utilized for the second part of this research, using instructor surveys, is Grounded theory. This theory was developed by two sociologists, Barney Glaser and Anselm Strauss, in their research on dying hospital patients. It was formerly known as constant comparative method (Glaser and Strauss, 1967). It is quite different from other theoretical frameworks because it is established after data has been collected, and not before data collection. Grounded theory is a systematic approach in social sciences that involves constructing theory through data analysis (Aldiabat and Carol-Lynne, 2011). It is quite different from the traditional research design where a researcher has a theory in mind before embarking on the research. A grounded theorist aims to acquire knowledge about the socially-shared meaning that forms the behaviors and the reality of the participants in a study. This theory helps close the gap between theory and empirical research (Corbin and Strauss, 1990; Strauss and Corbin, 1994; Allan, 2003; Faggiolani, 2011).

High Impact Practices

High impact practices (HIPs) are widely tested teaching and learning practices that have proven to be helpful for college students of various backgrounds. They can be done in multiple forms, depending on the school's and student's priorities and situations (Kuh, 2012). Due to their positive impact on student learning and retention, Gonyea, Kinzie, Kuh, and Laird (2008) recommend that all students in higher education participate in at least two high-impact practices, one in their first year and the other in their academic major (Gonyea et al. 2008). HIPs require considerable time and effort, enable learning outside of the classroom, involve meaningful interactions with faculty and students, encourage collaboration with diverse others, and provide frequent and substantive feedback. As a result, participation in these practices can be life-changing (Kuh, 2008). HIPs include first year seminars and experiences, common intellectual experiences, learning communities, writing intensive courses, collaborative assignments and projects, undergraduate research, diversity/global learning, service learning learning/ community-based learning, internships, and capstone courses and projects (Kuh, 2008). Brownell and Swaner (2009) assert that HIPs "had a positive impact on student performance or, at worst, a neutral impact" in a comprehensive review they did. Studies show that FG students, who are already struggling in higher education, were far less likely to participate in these activities (Finley 2011; Kuh 2012). If HIPs are practiced in introductory biology courses, it will be interesting to know how well they are done and their impacts on students especially the underrepresented minorities such as FG students. Inclusive teaching strategies taken into account in this research can also be considered high impact practices since they are both activities involved in meeting the needs of students of various backgrounds.

The theories considered in this research are constructivism and grounded theory. The first part of this study is based on constructivism as it is based on qualitative factors that can influence FG students' performance under various modes of summative assessment delivery in introductory biology. The second part of this study has its basis on survey data collected from faculty to explore how introductory biology is structured across universities in southeastern United States; this is a grounded theory approach.

CHAPTER 3

DELIVERY OF SUMMATIVE ASSESSMENT MATTERS FOR IMPROVING AT-RISK STUDENT LEARNING

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Abstract

Summative assessments are customarily used to evaluate ultimate student outcomes and typically occur less frequently during instruction than formative assessments. Much has been written about improving student outcomes using data gathered through formative assessment (focusing on classroom technique), however, few studies have examined how the use of summative assessments may influence student learning among at-risk groups of students. Summative assessments are typically used to evaluate how much learning has occurred. The following study investigates how summative assessments could be used to reduce the achievement gap among at-risk groups of students in an introductory biology course. Students were given low-stakes practice exams between high stakes mid-term exams. These practice questions were delivered in different modalities throughout three semesters in an introductory biology course. Survey questions were also given out at the end of each semester to identify student preferences for different modes of practice question delivery. Half of the mid-term examination was comprised of questions that evaluated higher-order cognitive skills. Students showed low preference for the mixed model of delivering practice exam questions, that is they completed some online and some during lecture; however, the overall result shows that all students including at-risk groups have the greatest performance when practice questions were delivered face-to-face during lectures.

Keywords: Summative assessment, formative assessment, higher-order cognitive skills, introductory biology, at-risk groups

Introduction

Even when active learning strategies are used, it has been observed that some students achieve more than others (students from lower-income households, first generation students and underrepresented minorities) academically (Kuh et al., 2011). Several factors (such as poverty, minority status, lower quality schools, flawed testing and assessment design) are responsible for the achievement gap in learning (Abbott et al., 2014). First generation (FG) students, who are first in the families to attend college, represent a sizeable minority in post-secondary schools. This special group of students has the tendency to report lower educational expectations, be less prepared academically, and receive less support from their families in planning and preparing for college than their peers whose parents attended college (Bush, 2007; Choy, 2001). While students whose parents have a college education tend to experience 'college as a continuation' of their academic and social experiences in high school, going to college often constitutes a 'disjunction' in the lives of FG students and their families (Engle, 2007).

Active learning improves student performance across science disciplines (Freeman et al., 2014) and when combined with frequent formative assessment can drastically reduce failure rates (Black & William, 1998; Brookhart et al., 2008; Fluckiger et al., 2010; Freeman et al 2011; Shepard, 2005; Tay, 2015*).* Successfully implementing contemporary teaching strategies such as active learning and effective assessment of learning in the classroom requires time and training; hence many college and university professors prefer the default position of lecturing (Allen & Tanner, 2005; George & Bragg, 1996; McCray et al., 2003). This demonstrates a great need for translational research that provides instructors with practical applications of discipline-based education research (Carroll et al., 2007). The following study aims to provide instructors with an example of how slight alterations in the delivery of existing assessments and course elements may improve student learning, especially for at-risk students.

Online learning can be used to supplement formative assessments (Gikandi et al., 2011; Hwang & Chang, 2011) as students can take the assessment at any time, repeatedly, and immediate feedback helps remedy weaknesses in their learning abilities. Student anxiety is also reduced when formative assessment opportunities are provided before summative assessments such as course exams (Wang et al., 2006; Zakrzewski & Bull, 1998). Can online delivery of summative assessment online also be used to improve learning? Rovai (2000) reported that instructors can and should use online interactions summatively as well as formatively. Apart from the general advantages of online learning, online delivery could lead to gains in class time for instruction and providing tests online in a secure, proctored computer-based testing laboratory may not simply provide a reasonable alternative method for gathering summative assessment data from students, but may actually be a preferable method for students (Cassady & Gridley, 2005).

The following study investigates how the delivery of frequent summative assessment, as an inclusive teaching practice, impacts student learning in a large enrollment introductory biology course that utilizes frequent active learning strategies in the classroom. The study analyzes exam data and end of semester surveys for three semesters of an introductory biology course for science majors and observes trends in student performance along three different modes of course delivery for post-lecture work in which each semester varied: in-class, online, and mixed (some online, some in-class) summative assessment delivery. Final exams were categorized by Bloom's Taxonomy of Learning and questions categorized as testing either higher order cognitive skills or lower order cognitive skills. More than half of the examination questions in each semester were at the higher-order cognitive levels. Student performance and preference for mode of delivery of summative assessments are fairly consistent with the mixed mode of course delivery being the least preferred and least successful in achieving higher order cognitive skill development. However, student viewpoints and performance on online and in-class summative assessments offer many interesting insights into how instructors may best use this approach as an inclusive practice to improve student learning.

Methods

Participants were students enrolled in an introductory biology course for majors at a southeastern regional university. Learning objectives for the course were based on concepts and science practices outlined in *Vision & Change* (Woodin et al., 2010) and the *Framework* (National Research Council, 2012). Class sizes range from 100 to 270 students with no more than 150 students in one section of the course that meets three hours per week. More than half of the students of the university were first generation students. The class is offered in every semester and is the second half of a two-semester introductory biology sequence for science majors. The majority of students are biology or health-related professions majors. All courses had the same instructor, the same course schedule, and the same post-lecture questions. The laboratory portion of the course meets for two hours once per week and some laboratory content is integrated with lecture content, while most lab content is complementary to lecture material.

Pre-lecture assignments (lower order questions) were delivered via the publisher-provided learning management system and post-lecture assessments (higher order questions) were delivered via the institution's learning management system (Desire2Learn). Post-lecture questions were assigned at the end of each lecture unit (every 3-4 lecture meetings) and, depending on semester, the delivery of these assignments varied. Post-lecture assignments included 10-20 practice exam questions at least two times between mid-term exams and implemented with the intent to provide students an opportunity to practice higher-order, more difficult questions in a lower-stakes environment. Exam questions varied each semester, but the content and average difficulty of the exams did not vary (see Table 1). Questions were designed as scenario-based multiple choice questions and ranged in Blooms level (Bloom, 1956; Crowe et al., 2008; Momsen et al., 2013). All mid-term exams and the final exams are cumulative and require students to continually build on and connect concepts throughout the course.

Table 1. Course structure and assessment delivery variation across three semesters. The course grade is based on the lecture components listed below (75%) and lab activities and assignments (25%).

	Semester 1	Semester 2	Semester 3
Student Enrollment	97	231	72

<table>
<tr><td>Pre-Lecture Homework

Weight: 16%</td><td colspan="3">• Online publisher-provided guided reading questions (20-30 questions per chapter) graded on percent completion.
• Online publisher-provided chapter quizzes (10-20 questions per chapter) graded on percent correct.
• All pre-lecture assignments due the night prior to coverage of topics in lecture the next day.
• Frequency: 4-6 assignments per week</td></tr>
<tr><td>In-Class Exercises

Weight: 15%</td><td colspan="3">• Lectures broken down into 10-20 minute mini-lectures followed by activity or clicker questions.
• 1-2 Group assignments per lecture period in the form of a group writing assignment or other activity turned in for grading.
• Clickers used almost every lecture period graded by participation only.
• Frequency: 2-3 per lecture</td></tr>
<tr><td>Post-Lecture Assessments

Weight: 4%</td><td>MIXED
• Instructor created exam practice questions (10-20 questions) half delivered online via D2L quiz and half delivered in-class</td><td>ONLINE
• Instructor created exam practice questions (10-20 questions) delivered online via D2L quiz.</td><td>IN-CLASS
• Instructor created exam practice questions (10-20 questions) delivered in-class via handout or</td></tr>
</table>

	via handout or clicker questions. • Frequency: 2 per month	• Frequency: 2 per month	clicker questions. • Frequency: 2 per month
Exams Weight: 40%	3 Cumulative Mid-Term Exams (combined 27% of overall grade) 1 Cumulative Final Exam (13% of overall grade)* Frequency: One per month		

*This is the exam evaluated using Bloom's taxonomy of learning (Crowe et al., 2008).

Modes of Delivery

During this study, we explored how three different modes of delivering post-lecture assignments, comprised of higher-order practice exam questions, impact student performance. The online mode was delivered solely via D2L, the in-class mode was delivered exclusively during designated lecture periods, and the mixed mode alternated between delivery online and delivery during lectures.

For online delivery, students were given three attempts to complete the assignments and the grade was calculated as the average of all three attempts. The only feedback provided after an online attempt was whether or not the student answered a question correctly or incorrectly, no answer key was provided. Feedback for online work was structured in this way to encourage reflection rather than process of elimination.

During in-class delivery of post-lecture assignments students worked together in peer groups and were able to ask questions from the instructor and teaching assistants. The teaching assistants are students who previously took the course and volunteered to tutor students certain hours after class. They also attend classes with the students and meet with the instructor from time to time. The practice questions were provided either on paper or delivered via a student response system (i.e. clicker, smartphone application, etc.) Student teaching assistants were encouraged not to provide direct confirmation of whether or not students were correct, but to guide and facilitate learning as they are trained to do with other in-class activities. All student work was collected and graded for completion. The classes are large enrollment classes and all in-class work (including these post lecture practice tests) are always graded on completion.

Student Demographics

The institution provided all student demographic information typically collected from university admissions or financial aid applications (e.g. FAFSA). Student demographics include: ethnicity, URM-status, PELL Recipient-status, Low-socioeconomic status, Father Highest Grade, Mother Highest Grade, Secondary School GPA, High School GPA, ACT Score, Science or Non-science major status. Out of all these, the major factors considered were URM-status, low socioeconomic status (Pell Grant eligible), low high school GPA (<2.5), and ACT score below benchmark (<23 for science). Any student whose father and/or mother had less than a four-year college degree was considered a first generation student.

Blooming Exam Questions

Bloom's Taxonomy of Learning was used to rate the cognitive level of cumulative final exam questions across the three semesters (Bloom, 1956; Crowe et al., 2008; Momsen et al., 2013). The lower level questions are categorized as 1 and 2 while higher-level questions are categorized as 3 and 4. The course the study was conducted in is a freshmen-level introductory course where very few questions were categorized as a 5 or 6. More than half of final exam questions in each semester were categorized as testing higher-order cognitive skills.

<u>Sample Final Exam Questions</u>

1. What immediately follows meiosis I during oogenesis?
   a) DNA replication
   b) Crossing over
   c) Metaphase II
   d) Prophase I
   e) Fertilization

2. Reptile eggs are ________ desiccant-resistant than amphibian eggs, because ________.
   a) Less; they contain less yolk
   b) Less; they contain more yolk
   c) More; they have a shell
   d) More; they are viviparous

3. Which of the following is most likely true of plant nutrients?
   a) Nitrogen is an essential component of sucrose.
   b) Phosphorous is essential for active transport of sucrose.
   c) Potassium is essential for maintaining passive transport of water.
   d) A & B only
   e) B & C only

4. Most doctors treat dumping syndrome by recommending changes in diet. Doctors will typically recommend patients choose complex carbohydrates like whole grains and recommend lying down after a meal. Why do these treatments aid in absorption of nutrients and prevent dumping?
   A) Lying down allows food to spend less time in the small intestines.
   B) Complex carbohydrates break down more quickly than simple sugars.
   C) Lying down reduces chemical digestion.
   D) Complex carbohydrates contain more nutrients than simple carbohydrates.
   E) All of the above.

Figure 3.1 Sample of final exam questions that test both lower order (Questions 1 and 2) and higher order (Questions 3 and 4) cognitive skills.

End of Semester Surveys

Each semester students were asked to fill out a 30-question, 5-point Likert-type end of semester survey about different elements of the course (Appendix A). Students received extra credit for completing the survey. Students were given a description of the post-lecture assignments and asked if they thought the platform was effective and were asked to provide comments about the format and delivery of the assignments.

Results

Higher Order Cognitive Skills vs. Lower Order Cognitive Skills

Questions at the end of each semester tested the higher order cognitive skills (HOCS) of the students more than their lower order cognitive skills. The in-class mode of course delivery recorded the highest average student score on HOCS questions on the final exam (67.2 ± 2.0%) while the lowest average student score on HOCS questions was observed when the mode of course delivery was all online (52.7 ± 0.8%). The mixed mode of course delivery had an average student score of 63.3 ± 1.4% on higher order cognitive questions (Figure 3.2).

For lower order cognitive skill questions (LOCS), the in-class mode of course delivery recorded the highest average student score (71.4 ± 1.7%) on the final exam while the lowest average student score was observed when the mode of course delivery was all online (61.6 ± 1.1%). The mixed mode of course delivery had an average student score of 70.2 ± 1.6% on higher order cognitive questions.

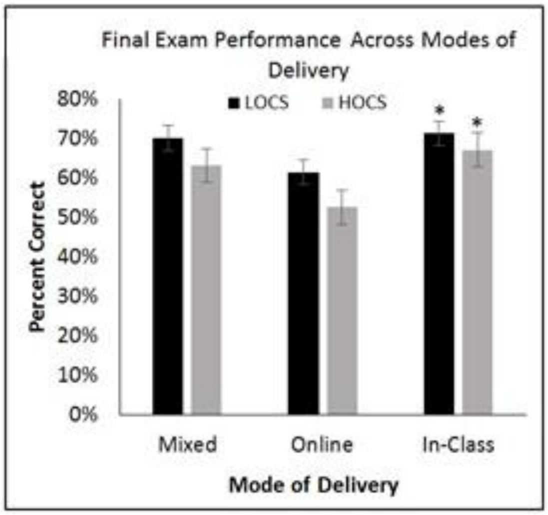

Figure 3.2. Average student score on lower order cognitive questions (LOCS) and higher order cognitive questions (HOCS) over the three modes of summative assessment delivery. *p<0.001

Student Preference

Students' responses on end of semester surveys indicate students' rating of effectiveness (percentage indicating Very effective or somewhat effective) was highest for the online (87.35%) and in-class (87.38%) modes of course delivery. Fewer students (48.98%) indicated preference for the mixed mode of course delivery (Figure 3.3).

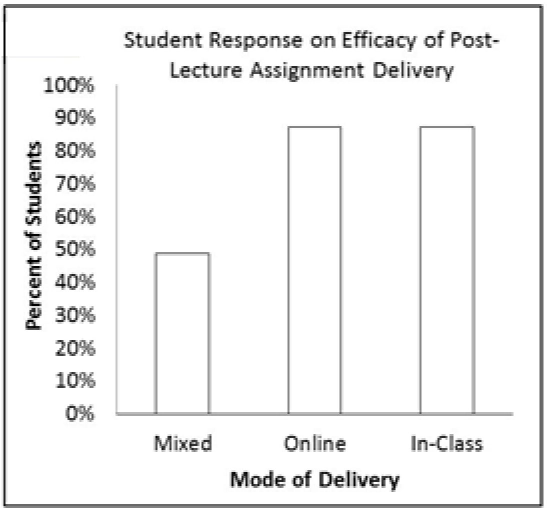

Figure 3.3 Percentage of students in the course that indicate the mode of delivery used for their course was “Very Effective” to “Somewhat Effective” for completing post-lecture assignments.

Student At-risk Factors

Students with low high school GPA (<2.5) recorded their highest performance during the online and mixed modes of course delivery. The underrepresented minorities (URMs) and students with low socioeconomic status (Pell Grant eligible) had their highest performance when the course was delivered in class. The mixed mode of course delivery favored FG students.

When the course was delivered in class, URMs made up about 30% (21) of the class composition, students with low socioeconomic status were one-third of the class (24), about 40% (27) were FG students, and students with low high school GPA were a little above 5% (4) of the students.

In the online mode of course delivery, above 15% (38) of the class were URMs, one-third of the class (77) were students with low socioeconomic status, about 30% (69) were FG students, and 2% (5) were students with low high school GPA.

During the mixed mode of course delivery, about 10% (9) of the class were URMs, students with low socioeconomic status (36) and FG students (35) each made up about 40% of the class while a little above 3% of the class were students with low high school GPA.

Exam Content Analysis

Over the three semesters, 38.2% of the questions tested lower order cognitive skills while 61.8% of the questions tested higher order cognitive skills. At the end of semester 1 (mixed mode), 37.9% of the examination questions tested lower order cognitive skills while 62.1% tested higher order cognitive skills. At the end of semester 2 (online mode), 36.7% of the questions tested the students' knowledge and comprehension skills while 63.3% tested their application and analytical skills. During the third semester (in class mode), 40% of the exam questions tested the students' lower order cognitive skills while 60% tested their higher order cognitive skills (Table 2).

Table 2. The percentage composition of examination questions at the end of each semester according to Bloom's taxonomy across the three semesters (Bloom, 1956)

	Knowledge	Comprehension	Application	Analysis
Semester 1	17.6%	20.3%	8.3%	53.8%
Semester 2	11.7%	25%	36.7%	26.6%

Semester 3	20%	20%	20%	40%
	38.2% Lower Order Questions		61.8% Higher Order Questions	

Discussion

Summative assessment is an assessment of learning that is usually used for high-stakes purposes. This study aims to know if the delivery of summative assessment in the form of frequent post-lecture practice exam questions improves student learning. The result over three semesters shows that student performance is not only based on the type of assessment, but also on the mode of course delivery as the student performance varied under different modes of course delivery. The analysis of the end of semester survey shows that students preferred the online and in-class modes of course delivery but had low performance at the end of the online mode of course delivery. The highest student performance on both lower and higher order cognitive questions was observed during the in-class mode of course delivery.

At-Risk Student Achievement

Different at-risk students benefit from different modes of course delivery. Generally, URMs gained most when the course was delivered in class (47.62%). First generation students, unlike URMs generally, benefitted most from the mixed mode of course delivery (See Figure 3.4; 31.43%, p=0.031). Further study can address the reason for this disparity and factors that can increase students’ academic performance across all demographics should also be considered.

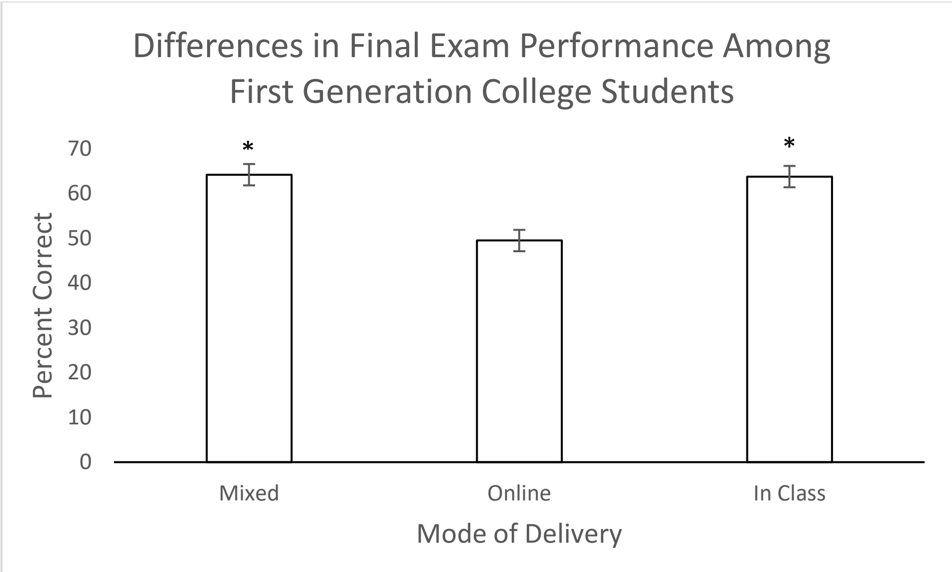

Figure 3.4 First generation college student scores (Mixed = 64.21% (35), Online = 49.50% (69), In class = 63.79% (27)) on HOCS questions across three different modes of delivery. *p<0.001

Influence of Peer Instruction on In Class and Mixed Delivery

Mixed and In Class modes demonstrate the greatest influence on student HOCS development and could point to the influence that peer-learning and instructor feedback may play in closing achievement gaps. Findings from this study have led to various questions that can be appropriately addressed with studies conducted on a larger scale. The questions include: Can student preference for a mode of course delivery be closely associated with their academic performances? How does the use of peer learning aid at-risk student performance? Do other institutions/instructors offer highly structured courses with frequent, compulsory practice of higher-order cognitive skills?

Implications for Teaching Practice

If the same study were to be conducted on a larger scale, it would be important to know if student preference for a particular mode of course delivery is a true reflection of their performance as student performance did not match student preference in this study. As supported by Chen and his colleagues in their study of online learners, there is a possibility for enhanced student performance in the online mode if activities for feedback and interaction can be included (Chen et al., 2010). Further studies can explain what instructors should include in their teaching and assessments to accommodate all students, especially the at-risk groups, regardless of mode of course delivery.

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CHAPTER 4

COURSE STRUCTURE IN INTRODUCTORY BIOLOGY: A FACULTY SURVEY OF WHAT WORKS

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Abstract

Increased course structure has been known to improve student performance in introductory STEM courses by giving students opportunities to assess their progress from time to time. Several active learning strategies such as the use of clickers, case studies, and peer learning have been used when increasing the structure of a course. This study is based on an introductory biology instructor survey in southeastern universities across the United States to find out how they structure their biology courses and why they are structured that way. The results showed that most instructors used online activities before and after instruction. Time constraint, class size, and shortage of teaching assistants were considered the major barriers to having active learning strategies in class. Questions that tested student lower order cognitive skills were usually asked before and after class while instructors addressed questions that tested student higher order cognitive skills in class. The use of feedback, teaching evaluations, and challenges faced by at-risk students were also considered in the survey. This study serves as a basis for a broader study on what instructors can include in their teaching practice to promote student success in class, especially among at-risk groups, regardless of how different elements of the course are delivered.

Keywords: Course structure, assessment, faculty survey, active learning, introductory biology

Introduction

Course structure, the organization of content and other elements of a particular course, can heavily influence student performance (Koo et al., 2016; Lee et al., 2009; Saville et al., 2011) and, more recently, instructors have been experimenting with “hybridizing” or “flipping” different elements of their courses by placing content or other assignments online (Akono et al., 2015). A longitudinal qualitative study applied four analytic frames (cognition and information processing, student engagement, age cohort, and technology use) to ascertain the relationship between course structure and student performance and determined that prerequisites, course and classroom environment, assignment frequency and type, and type of instructor all play important roles in influencing student performance (Dean and Fornaciari, 2014). Additionally, students may be easily distracted and might not possess even rudimentary learning skills, therefore instructors may need to provide additional metacognitive instruction in order for students to reach full potential (Rachal et al., 2007). Trying to address all of these barriers to learning within a course can be a daunting task as it requires purposeful arrangement of activities before, during, and after teaching the topics in any course.

A lot of factors contribute to the structure of a course or instructional design, but according to Gagné and his colleagues (2005), all course structures should include analysis, design, development, implementation, and evaluation. To effectively structure a course, it is important that faculty have an understanding of instructional design because it greatly affects the quality of student learning (Fink, 2013). Dick, Carey, and Carey (2006) postulate that it is important to consider situational factors (learners, instructor, instructional materials, delivery system, and the learning and performance environments) in designing any course as these factors must interact with each other to produce desirable learning outcomes.

Active learning strategies have undoubtedly been known to improve student performance and reduce failure rates in various disciplines, especially when combined with frequent formative assessments (Black and William, 1998; Brookhart et al., 2008; Fluckiger et al., 2010*;* Freeman et al., 2007; Freeman et al., 2011; Shepard, 2005; Tay, 2015). Many factors such as course structure, class size, peer learning, self-motivation, feedback use, availability of teaching assistants (TAs), type of questions asked (higher order or lower order thinking questions), and when the questions are asked (before, during, and after lectures) can contribute to student success in STEM fields. These factors can be student-related, teacher-related, school-related, or family-related (National Education Association, 2008; Ptucha and Savakis, 2012; Xie et al., 2015), however student viewpoints and performance can offer many interesting insights into how instructors may best structure their course to improve student learning.

Previous studies show that student performance is not only based on the type of assessment, but also on the mode in which the assessment is delivered (online, in-class, or some of both) (Agboola and Hiatt, 2017). Student surveys also indicated a preference for online and in-class modes of assessment delivery; however, exam performance under online only conditions were much lower than compared to in-class delivery of assessments (Agboola and Hiatt, 2017). The role of peer learning and instructor feedback may also play a large role in why assessment delivery is more successful in class, so this research project also aims to find out how other faculty approach higher-order question delivery and whether or not they also utilize peer learning.

Given the influence of course structure on exam performance, this study explores how different introductory biology courses are structured across southeastern universities in the US. Particularly, it explores if there are any factors that may influence whether or not certain elements of a course are utilized more frequently than others or if there are relationships between faculty demographics and the course structure they describe. This information could be useful to explore the benefits and constraints of different teaching approaches and could be used to help other instructors learn how to best implement contemporary teaching strategies.

Research Design & Methodology

This mixed-methods study utilizes grounded theory to explore trends among faculty responses to a survey about their course structure. Grounded theory involves constructing theory through data analysis, so it is usually established after data has been collected; it aims to obtain information about the socially-shared values that shape the behaviors and the reality of the participants in any study (Aldiabat and Carol-Lynne, 2011; Allan, 2003 Corbin and Strauss, 1990; Faggiolani, 2011; Strauss and Corbin, 1994). Introductory Biology instructors across universities in the southeastern United States were contacted and asked to answer questions about active learning strategies they incorporate into their course, the period the strategies are implemented (before, during or after the course), the level of difficulty of questions asked (whether questions test students’ higher order cognitive skills (HOCS) or lower order cognitive skills (LOCS)), and their rationale behind the course structure described.

Quantitative survey

A survey was sent out to southeastern introductory biology teachers to know about the active learning strategies used in their teaching. Some members of National Association of Biology Teachers (NABT) who showed interest in introductory Biology also participated in the survey. The active learning strategies considered were guided-reading questions, chapter quizzes, lecture guides, vocabulary/terminology quizzes, scenario-based problems, case studies, interactive online quizzes, practice test/exam questions, worksheets, concept maps, informal (short answer questions and paragraph essays), and formal writing assignments (lab reports). The frequency of use of these strategies was also considered (whether the strategies were used all of the time, most of the time, some of the time, or never). The survey (Appendix B) includes the period students complete the activities (whether activities are completed before, during, or after lecture/lab or if it was a mix of in-class and out of class), gender, race, level of student-to-teacher interaction outside class, class size, teaching experience, level of satisfaction on the job (on a four-point Likert scale from “very dissatisfied” to “very satisfied”), and level of faculty recognition in research and teaching (on a five-point Likert scale from “extremely well” to “not at all well”).

Qualitative survey

A follow-up survey was sent out to participants that responded to the first survey for better understanding of the kinds of activities and assignments their students complete in different portions of their course. Pre-lesson, post-lesson, and lecture period were defined. Pre-lesson was defined as before an instructional unit or collection of concepts are taught, post-lesson meant following/immediately after an instructional unit or collection of concept are taught, while lecture period referred to the scheduled class meeting time. Open-ended questions that addressed peer learning, higher and lower order cognitive skill questions, activities that involved in pre-lesson, during lesson or post-lesson work, rationale behind course structure, barriers to having those activities in class, means of providing feedback to students, use of teaching evaluations, challenges of at-risk students, and method and frequency of assessments are asked here (Appendix C).

Results & Discussion

The result of the first survey shows that equal number of males and females responded. 116 instructors were contacted for the first survey and 32 responded. Only 8 out of the 32 instructors contacted in the second survey responded. Most pre-lecture and post-lecture activities are usually delivered online while some of the in-class activities are delivered face-to-face. Very few respondents use the mixed method (some in-class, some online) delivery of activities (Figure 4.1). Many of the instructors utilize peer or team-based learning, clickers, case studies, problem, or research-based learning as active learning strategies while few use game-based learning (Figure 4.2). Lecture guides, formal and informal writing assignments, and practice test/exam questions are the more frequently used activities. Lecture guides and informal writing assignments are used before and during lecture/lab respectively while practice test/exam questions and formal writing assignments are usually done after lecture/lab. Sometimes, guided reading questions and interactive online quizzes are done before and after lab/lecture, respectively, while case studies and scenario-based problems are activities done during lab/lecture (Figure 4.3). Most instructors had very few students interact with them face-to-face outside of lecture for help. Most participants indicated they were willing to provide information about their course and students for future study.

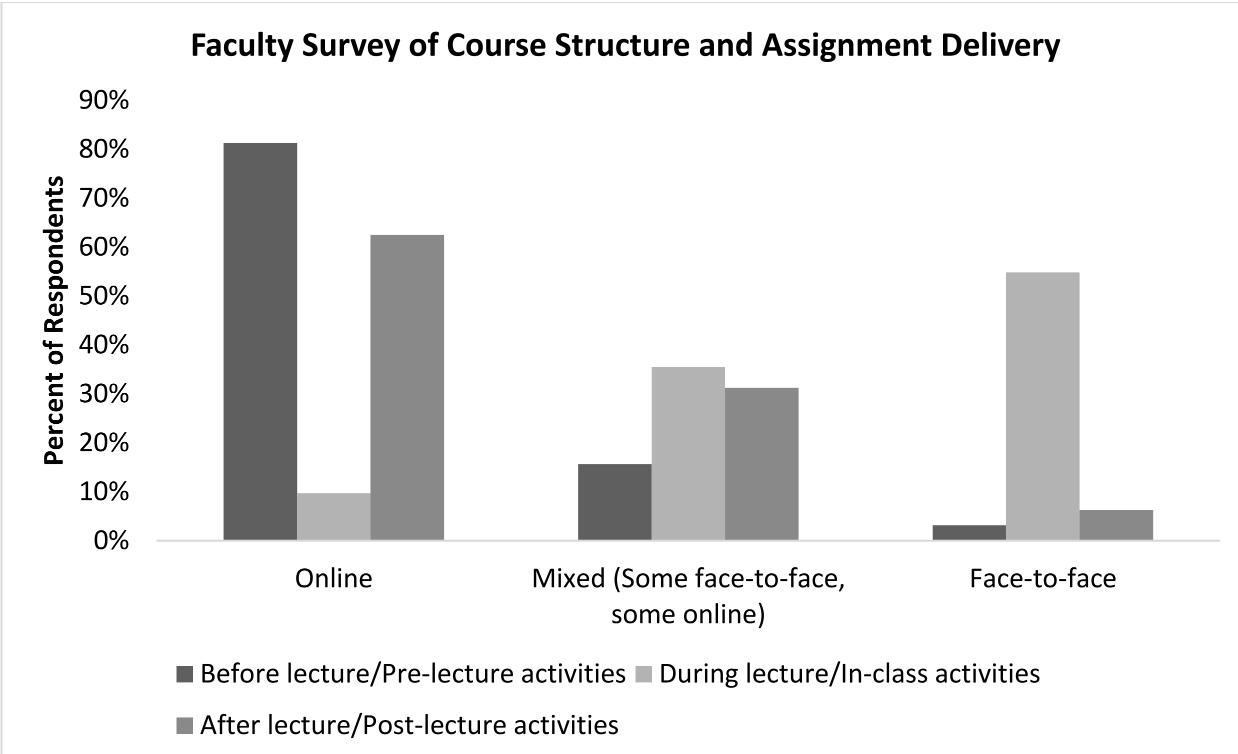

Figure 4.1 Lecture activities in the online, mixed, and face-to-face modes of course delivery before, during, and after lecture (N=8).

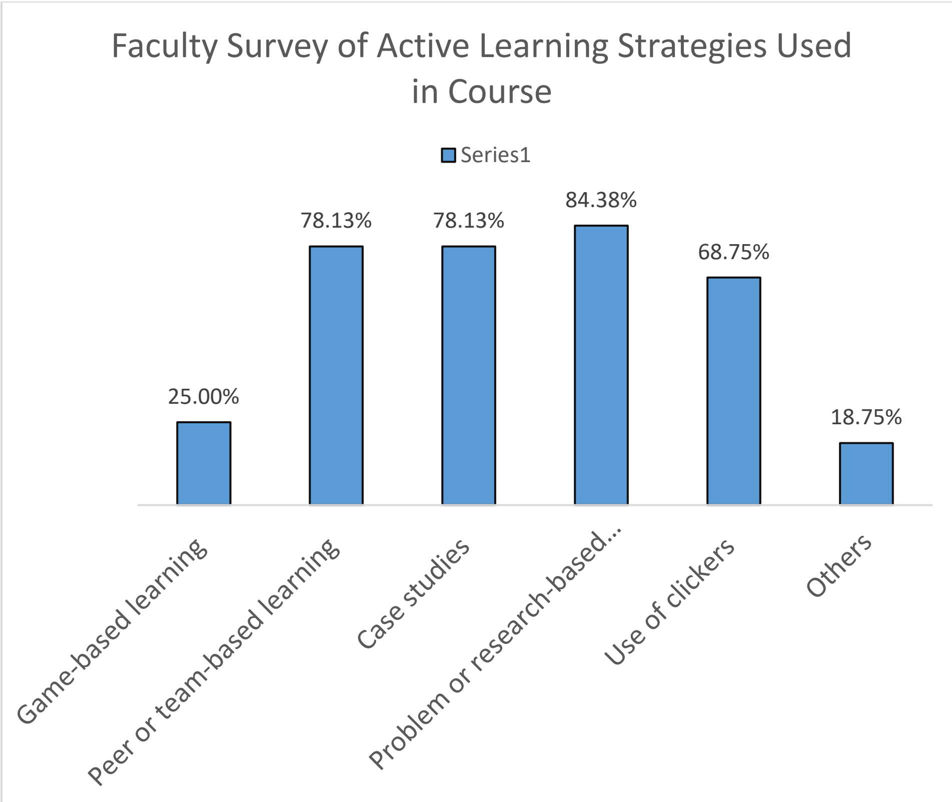

Figure 4.2 Types of active learning strategies used (N=8).

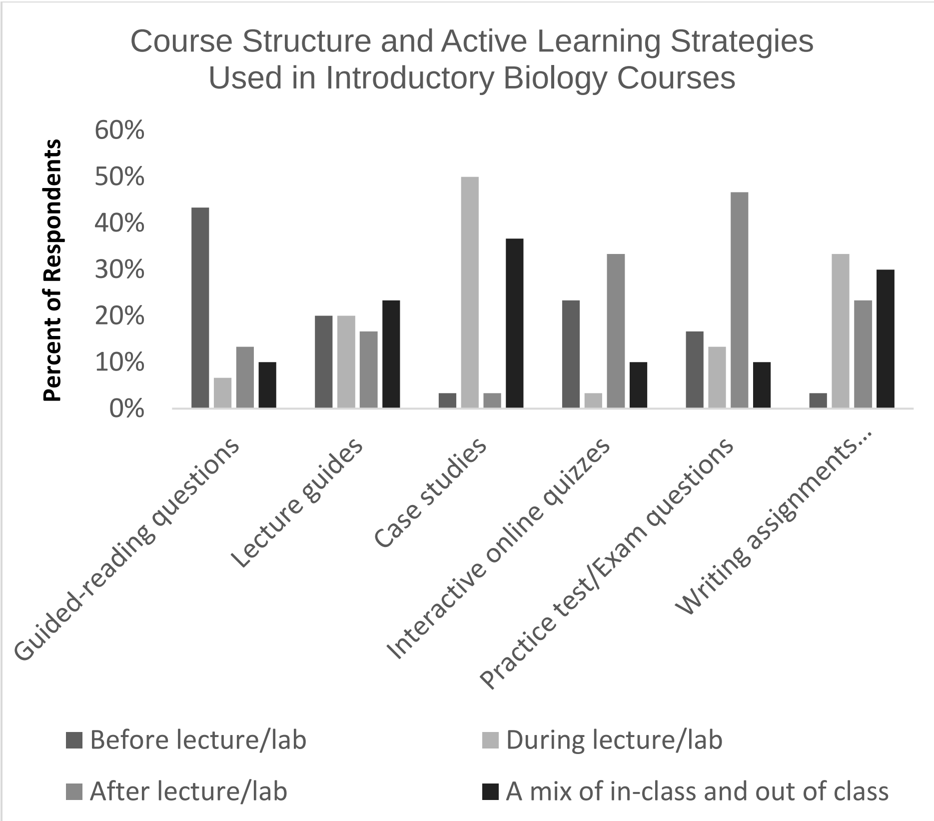

Figure 4.3 Active learning strategies in online, mixed, and face-to-face modes of course delivery before, during, after lecture, and a mix of in-class and out of class (N=8).

In the second survey, peer learning was defined in various ways. The definitions given for peer learning is in the table 3 below:

Table 3. Definitions of Peer Learning Provided by Introductory Biology Faculty.

Students assisting one another in the learning process but constructing learning together.
Group work on problem solving activities

Forming groups to which students belong, then assigning a list of questions to be answered while in class. The students are not allowed to use notes or online materials and must complete one answer sheet that reflects the thinking of all 4-5 members of the group.
Time in class when students spend time discussing/explaining topics to one another. This may include student-to-student or peer instructor-to-student learning. Peer instructors are students who have already completed the class with an A or B grade and are volunteering their time.
Students sharing their ideas about a concept or question with one another, each presenting evidence supporting their ideas.
Students helping one another to learn concepts.
Peer learning occurs anytime a student learns something from another student.

All instructors used peer learning in class, a few used it online before class, and some used it after class. Instructors defined lower order cognitive skill (LOCS) questions as clicker questions that address the knowledge and comprehension skills of the students. Higher order cognitive skill (HOCS) questions were defined as questions that test students' application, analysis, and synthesis skills. Activities used to test HOCS include Peer-Oriented Guided Inquiry Learning (POGIL), data interpretation, and case studies.

A lot of respondents showed that less than 25% of their entire course is either online pre-lesson or online post-lesson work. In these hybridized courses, pre-lesson activities (online quizzes, readings, surveys, and questionnaires) did not require students' higher order thinking skills while post-lesson activities (online videos, pre-lesson work, end-of-chapter quiz, online discussion questions, digital writing assignments, and quizzes) were HOCS activities. Mastering Biology and animations could be used as pre- or post-lesson activities. Most instructors indicated that the majority of the course is comprised of face-to-face instruction or lessons. The activities used face-to-face usually required HOCS and they include clicker questions, discussion questions, data interpretation and analysis, think-pair-share, videos, case studies, mini lectures, peer assessments, drawings, and mini essays.

Instructors gave a lot of reasons for structuring their course the way they did. They include class size, active learning strategies to address misconceptions and promote critical thinking skills, pre-lecture activities to reduce in-class time, pre-lecture work to promote application skills, slow evaluation with available technology, flipped model for students to work on LOCS on their own while teacher assists with HOCS, build from LOCS to HOCS in class to monitor students, and best practices obtained through student-centered learning. Time constraints, class size, student unpreparedness and laziness, shortage of teaching assistants (TAs), and reliance on multiple choice questions (MCQs), were considered the biggest barriers to delivering and/or completing pre-lesson and post-lesson activities in class. Feedback, using grades and/or peer assessment, were provided to students through oral or written methods individually or as a group.

Assessments were done at various intervals (daily, twice a week, almost every lecture period) using online items, in-class clicker questions, reviewing in-class group exercises, summative assessments, pre-class quizzes, post-class homework in each unit, in-class learning activities, and formative assessments. Certain instructors found teaching evaluations useful as they were able to recognize the effectiveness of peer learning, student aversion for notecards, and the need for pre-class quizzes to be taken more than once for students to learn materials before class. A particular instructor acknowledged quantitative analysis of feedback to categorize comments as positive or negative as a teaching strategy considered useful by the instructor may not be well received by the students. Another instructor complained of untimely access to feedback. Below is the instructor's response "Rarely do student evaluations provide meaningful feedback for that particular class as we cannot access them until post-course. We do not require peer feedback and it is rarely implemented here." Student mindset and preparedness for school, lack of sense of belonging in STEM classroom, financial constraints, inability to adapt to new method of learning, unwillingness to seek help, not knowing how to study actively, and inability to use feedback appropriately were considered the biggest challenges these at-risk students face in succeeding in an introductory science course.

Results from both surveys show that the major active learning strategies used are peer-learning, clickers, problem-based learning, and case studies. Identifying the effectiveness of each learning strategy and when each strategy can best be utilized (pre-, during or post-lecture/lab) will be useful. Many instructors delivered most of their pre- and post-lecture/lab activities online and have provided various reasons for doing so. If measures to overcome barriers to doing the activities in class (time constraints, class size, student unpreparedness and laziness shortage of teaching assistants (TAs)) were provided, will instructors actually use the in-class mode of course delivery? If yes, what difference will it make on student performance?

Post-lesson activities usually test HOCS while pre-lesson activities test LOCS. The rationale behind this, as provided by one of the instructors, could be the need to build from LOCS to HOCS in class to monitor students. According to the instructor, students can work on LOCS activities on their own before and/or after class while HOCS activities can be addressed in class under the instructor's supervision. It will be interesting to know how often feedback (either oral or written, individual or as a group) is provided and whether students actually use the feedback provided. This could be reflected in their subsequent performance in the course. All the instructors in the second survey use peer learning. It will be helpful to know the effect of peer learning on student performance despite doing most of the activities online. A very low percentage of students seek help from their instructors outside class. It will be helpful to know how to promote student-to-teacher interaction outside class as this might greatly influence student performance, especially the performance of the underrepresented minorities.

This study is not without limitations. There was a very low response rate from instructors and this resulted in limited data to analyze. Almost all respondents from the first survey are White/Caucasian. This could have introduced ethnicity bias as instructors of other ethnicities might have structured their courses in the same or a different way and gotten the same or different results. It was also difficult to compare the different modes of course delivery due to the inability to influence the mode of course delivery used. Most participants agreed to provide information about their course and students for future study in the first survey but in the follow-up survey, examination questions were not provided, thereby making it difficult to evaluate the level of difficulty of examination questions asked.

Over a longer period of time, a better result can be achieved if this study were carried out on a larger scale (universities all over the United States) with the focus still on Introductory Biology courses. Class size, TA availability, effect of peer learning, and feedback use are factors that could be considered in such study. Questions that can be answered include: Can student preference for a mode of course delivery be closely associated with their academic performances? How should instructors structure their courses to accommodate all students, especially the at-risk groups, regardless of the mode of course delivery? How does the use of peer learning aid at-risk student performance? Do other institutions/instructors offer highly structured courses with frequent, compulsory practice of higher-order cognitive skills? It will also be interesting to see student performance based on different course structures used by the instructors. Findings from such studies can inform us on how best to structure introductory biology courses and how those elements are best delivered and this can be applied to other STEM courses and possibly non-STEM courses too.

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CHAPTER 5

IMPLICATIONS FOR EDUCATORS

Course structure plays a crucial role in students' learning as it determines learning outcomes. It is usually made up of the analysis, design, development, implementation, and evaluation of a course. Learners, instructor, instructional materials, and the learning and performance environments are situational factors in a course structure (Gagné et al. 2005; Dick and Carey, 2006; Fink, 2013). The first part of this research focuses on the role evaluation (summative assessment) plays on learners (FG students) in an introductory biology course. Apart from the effect of summative assessment (post-lecture assessments that account for 4% of students' grades), the role played by different modes of assessment is also seen on variation in the students' results under different modes of assessment. This shows that student performance is not only based on the type of assessment, but also on the mode that assessment is delivered. It can be difficult to establish a direct relationship between modes of course delivery and student outcomes but suggests clarity of instructions, constant teacher-to-student or student-to-peer interaction, timely feedback, and adequate time to practice skills and meet requirements as important principles in any course structure regardless of the delivery method (Misko, 1999). However, it is important to know if a direct relationship can be made between modes of course delivery and student performance on a broader scale in other courses so that instructors can consider both assessment and mode of course delivery when designing their courses.

Course Modality and Structure Matters

The in-class mode of course delivery shows the highest student performance on both lower and higher order cognitive questions but students actually preferred both online and in-class modes of course delivery. Studies have shown that most students prefer taking courses online than in class (Fillion et al. 2009; Harrington and Loffredo, 2010). Future research can look into relationship between FG students' preference for and performance in different modes of course delivery as it was impossible to obtain this information from this study since students did not include their names on the end of semester survey completed. Do FG students perform best in the mode of delivery they prefer most? The research can attempt to answer the same question on other URMs, students with low-socioeconomic status, students with low high school GPA, and students with low ACT score. Information gotten here could be used by the instructor in mapping out inclusive teaching strategies.

Results from a research of 152 college students from three universities in the southeast show that students who have previously taken lots of online courses tend to prefer online courses more than those who have not. Online courses are considered more difficult or of the same difficulty as face-to-face courses. Lack of contact with instructors was identified as a major disadvantage associated with online instruction (Glover and Lewis, 2012). The question to be asked here is, "Do students' preference match their performance?" Further studies can show if there is a correlation between student preference and student performance as this can help institution decide courses that can be taught under each mode of course delivery to get optimal student performance.

Comparison between the completion rates of online assignments under the mixed mode to the online mode of post-lecture assessments can be made to find out if lower completion rate of online assignments contributes to students' poor performance. Several studies have shown that technology can be a means of distraction to students in class in the presence of the instructor (Taneja et al. 2015; Beland and Murphy, 2016; Munro et al. 2017), but when students are left on their own to complete assignments online, how well can they discipline themselves to stay focused? Time management is another factor to be considered as this greatly affects students' performance (Abdulghani et al. 2014; Hamzah et al. 2014; Aduke, 2015). If students wait till the last minute to complete their assignments, and also get distracted at the same time, their academic performance can be negatively affected (Tauber, 2013).

Making the Most of Face-To-Face Instruction in a Highly Structured Course

At-risk groups have the greatest performance when practice questions were delivered face-to-face during lectures. It will be important to know if peer learning has a role to play in this because peer learning in form of supplemental instruction was used in this study and several studies have emphasized the importance of peer learning (Kochenour et al. 1997; Bowles and Jones, 2003; Longfellow et al. 2008). Studies on larger scales can be done to investigate the importance of peer learning in at-risk groups' performance and findings can be applied to other STEM courses. Further study can look into factors that can increase students' academic performance across all demographics.

Results from the faculty survey indicate how introductory biology courses are structured across southeastern universities in the US. Instructors actually offer highly structured courses but the practice of higher-order cognitive skills is usually mainly during lesson (in class). An instructor provided the need to monitor students on HOCS activities as the justification for doing so. While this approach may be good for formative assessments and active learning, it can be a challenge in preparing students for performing well on summative assessments because summative assessments usually involve HOCS questions and students may not be able to accurately answer questions with such level of difficulty without assistance. The shortcoming in this approach is the inability of students to improve their critical thinking skills. Further study can investigate when best to ask HOCS questions and the consequence on students overall performance at the end an instructional unit.

Learning More About the Efficacy of Online Components in a Course

Most instructors use online activities before and after instruction. It is possible that compared to any other method, it is the easiest way to communicate course content and provide feedback to students before and after class. It will be worthwhile to know what kind of activities are put online and if measures are put in place to ensure that students actually do these activities. If students actually do them, how has it affected their performance? What are the other alternatives to having pre- and post-lesson activities online? How feasible are these alternatives? What are the barriers to these alternatives? These are questions further studies can address.

Overcoming Challenges in Implementing Contemporary Teaching Strategies

Time constraint and class size were major barriers to having these activities in class. These are fixed factors that instructors have to continually deal with. The institution can organize seminars on time management for both instructors and students to solve the problem. In a large class, instructors may find it challenging to monitor all the students. Some results of large class size, supported by practical evidence, are reduced students' level of active involvement in the learning process, decreased frequency and quality of instructor interaction with and feedback to students, low students' depth of thinking inside the classroom, and low students' academic achievement (learning) and academic performance (grades) (Cuseo, 2007). This can be resolved on the institutional level. An agreement on the appropriate class size can be made ahead of a school session and strictly adhered to once the school resumes. The role of TAs cannot be overemphasized. They are very useful "tools" for the instructors, especially in a large classroom setting (Hoefnagels, 2002). However, when they are available in small number, supplemental instructors (available after class) can be very useful as some students are willing to seek help outside the classroom environment. It will be worthwhile to see if instructors will do the activities in class if measures to overcome barriers to doing the activities in class were provided and the effect doing the activities in class will have on student performance.

It will be informative to know if students actually make use of the feedback their instructors give them and if the method used to provide the feedback can be applied to all students or is specific to a group of students. Peer assessment is one of the means identified to provide feedback. Do students actually take feedback from fellow students seriously and put it to good use? This could reflect on their performance. Some instructors claim to put the teaching evaluation given them to good use while others claim to be indifferent about it. How reliable is teaching evaluation from students as certain factors may influence the evaluations, thereby introducing some form of bias? For example, students in large classes may give lower overall ratings (evaluations) for course instruction delivered (Cuseo, 2007). Some students may have personal dislike for the course and/or the instructor. The effectiveness of teaching evaluation will rely deeply on its format, how often it is provided, and the individual(s) doing the evaluation (whether students or other instructors).

Instructors indicated using different active learning strategies at different periods. For example, clickers and case studies are usually used in class. Identifying the effectiveness of each learning strategy and when each strategy can best be utilized (pre-, during or post-lecture/lab) can be useful to instructors generally. Studies on a larger scale can provide insight into this. All the instructors agreed to using peer learning. It will be helpful to know how it is done, when it is done, and the effect on student performance. If peer learning was actually done online, it will be important to compare its effectiveness to when it is done in class as this could inform instructors on the better option. Very few students communicate with their instructors outside class. It will be highly useful to identify and work on measures that can promote student-to-teacher interaction outside class as this can greatly influence student performance, especially the performance of the underrepresented minorities (such as FG students).

Expanding Understanding of Course Structure and Modalities Nationwide

This study is a basis for a broader study as the results here may not reflect the opinions and preferences of other college faculty and students in other parts of the country. Over a longer period of time, if this study was carried out on a larger scale (universities all over the United States) with the focus on introductory biology courses at first, then other courses later, a lot of findings can be made from information on both the course and the students. It will be useful if students' grades can be accessed and assessed. Class size, TA availability, effect of peer learning, challenges faced by at-risk students, and the use of feedback are factors that could be considered in such study. All the questions asked in this research and more can be answered. It will also be interesting to see student performance based under different modes of course delivery.

Information from introductory biology course structure under different modes of course delivery can be applied to other STEM courses and possibly non-STEM courses too. Instructors will value information on how best to structure their classes to enhance student performance, specifically what to include in their teaching and assessments to accommodate all students, especially at-risk students, regardless of the mode of course delivery. Factors that determine whether or not certain elements of a course are utilized more frequently than others, relationships between faculty demographics and course structure, benefits and constraints of different teaching approaches, and how to best implement inclusive teaching strategies are examples of information that will be highly significant to instructors.

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APPENDICES

Appendix A: End of Semester Survey

End of Semester Survey – *7 BONUS POINTS* SURVEY NUMBER (on Scantron):___________

DO NOT put your name on this survey. Please answer each question to the best of your ability. When completed, turn in and sign by your name to ensure you receive credit for completion. Use the provided Scantron.

I. Content

Rank the following units according to how much you enjoyed learning the topic(s) according to the following scale (circle your response):

(A) Very Enjoyable **(B)** Somewhat Enjoyable **(C)** Neutral **(D)** Somewhat Not Enjoyable **(E)** Not Enjoyable at all

1. **Animal Development:** Animal reproductive systems, meiosis and gametogenesis, fertilization, comparative embryonic development, and formation of primary germ layers.
2. **Animal Organization and Regulation Pt. 1:** Introduction to tissue types, thermoregulation, musculoskeletal system, sensory system, nervous system, synaptic transmission and membrane potential.
3. **Animal Organization and Regulation Pt. 2:** Endocrine system, digestive system, osmoregulation, respiratory and circulatory systems.

4. **Plant Development and Organization:** Plant development and alternation of generations, nutrient and water transport, chemical and physical plant defenses.

Additional Comments about Content:

II. Course Management

Rank the following statements according to the following scale (circle your answer choice):

(A) Strongly Agree **(B)** Somewhat Agree **(C)** Neutral **(D)** Somewhat Disagree **(E)** Strongly Disagree

5. The distribution of points for homework, in-class work, and exams were fairly distributed.
6. The distribution of points for homework, in-class work, and exams were reflective of the amount of effort required for each component (e.g. the level of difficulty and time spent on homework was worth the amount of points earned for the assignment).
7. I liked that more points than needed were offered for homework and in-class activities (e.g. You found it useful that more than 250 points worth of homework points were available.)
8. Having the first exam be worth fewer points than the other exams helped relieve anxiety I had about the taking the first exam.

9. The overall structure of the class was consistent and the instructors expectations for the course were clear.
10. The CONNECT quiz questions adequately prepared me for in-class activity and discussion.
11. The CONNECT LearnSmart activities helped guide my reading of the book chapters/topics.
12. During lecture, I felt like my input was valuable and welcomed.
13. During lecture, I was comfortable talking with others and the instructor about the material.
14. The examples, activities, and discussion in-class related to the homework and textbook material.
15. Over the course of the semester, I gained confidence in my ability to participate and answer questions posed by the instructor.
16. It was possible to understand the material and perform well on exams without having to attend the lectures.
17. I often found myself bored or distracted during lecture.
18. The ‘clicker’ and multiple choice questions were helpful in checking my understanding of the subject.
19. Scenarios and activities used in class helped me better understand the material.
20. Interactions with the instructor were positive and informative.
21. I felt comfortable asking the instructor questions during lecture.
22. I felt comfortable asking the instructor questions outside of class (in person or via email).

23. I liked that the in-class work was graded on participation and not correctness.
24. The instructor did not judge or criticize my contributions to in-class discussion and activity.
25. The instructor provided effective resources for how to improve study skills and learning strategies.

Additional comments about course management:

III. Teaching Methods

Rank the following assignments according to how effective they were in helping you gain a better understanding of the course material. Please provide any additional comments or feedback.

(A) Very Effective **(B)** Somewhat Effective **(C)** neutral **(D)** Somewhat ineffective **(E)** Very ineffective

26. **Group Exam**: After the first exam, a group exam was given where you had the opportunity to earn up to 10 additional points towards the exam. Was the group exam effective in helping you better understand questions you missed or content you were unsure of?

27. **Scenario-based Lecture:** Throughout the course, we used several scenarios (E.g. Why do we care about fat, milk sickness, etc.) to cover lecture content. Was this effective at helping you better understand and connect content?

28. **Research-based question:** Throughout the course, we used several real examples from scientific research to explore different topics (e.g. leptin, kangaroo rats, etc.). Was this effective at helping you better understand how science works and how it is conducted?

29. **Peer-Group Learning**: Throughout the course, you were asked to collaborate on in-class assignments with a pre-selected group. Was this group/collaborative work effective at helping you work through problems and better understand the material?

30. **Post-Lecture Homework:** At the beginning of the semester much of you post-lecture homework was administered via D2L and you were offered multiple attempts at completion. During the second half of the course we focused on answering those post-lecture homework questions during lecture in the form of clickers or handouts. Was D2L a more effective platform for working through post-lecture homework questions?

Also, please provide a comment on which you prefer: Completing post-lecture homework on D2L or working through post-lecture homework in-class?

31. **Pre-Lecture Homework/McGraw-Hill Connect:** Each week you have multiple assignments due online via the McGraw-Hill Connect website. Was this online platform effective at preparing your for in-class lecture activities and discussion?

Additional comments about teaching methods:

Appendix B: Faculty Survey

Course Structure and Summative Assessment in Introductory Biology Courses

1. Participant Name

2. Email

3. Institution Name

Participant Demographics

Please answer the following:

4. What is your gender?

Mark only one oval.

Male

Female

Prefer not to answer

5. Which race/ethnicity best describes you?

Mark only one oval.

American Indian or Alaskan Native

Asian/Pacific Islander

Black or African American

Hispanic American

White/Caucasian

Multiple ethinicity

Other:

6. How long have you been teaching undergraduate science courses?

Mark only one oval.

15 years

6-10 years

11-20 years

More than 20 years

7. What type of position do you hold at your institution? (Select all that apply)

Check all that apply.

Part-time

Full-time

Temporary

Adjunct

Non-tenure Track

Tenure-track

Tenured

Other:

8. Have you had any of the following experiences? (Check Yes/No)

Mark only one oval per row.

Yes No

Held a teaching assistantship as a graduate student?

Held a research assistantship as a graduate student?

Been a department chairperson?

Held a major faculty-wide office, such as deanship?

Served on a committee charged with implementing assessment of student learning?

Supervised student teaching assistants?

Received an outstanding teaching award?

Supervised student research assistants?

Received a research award?

Been a staff member or fellow of a campus teaching and learning center?

Served on an institutional program review board?

Revised your courses based on student assessment information?

9. What proportion of your teaching load is comprised of the following types of courses in a typical academic year?

Mark only one oval per row.

All Most Some None

Remedial and developmental classes

Courses that meet general education requirements

Lower-division undergraduate courses

Upper-division undergraduate courses

Graduate level courses

10. How satisfied or dissatisfied are you with the following aspects of your position at your institution?

Mark only one oval per row.

Very dissatisfied

Somewhat dissatisfied

Somewhat satisfied

Very satisfied

Your workload

Your job security

Opportunity for advancement

Department support for promotion and tenure

Quality of students you teach

Collegiality in your department

Relationships with administrators

Support for teaching and learning

Freedom to do outside consulting

Support for assessment activities

Your salary/benefits

Opportunities for professional development

Institutional Information

Please answer the following:

11. How well does your institution recognize faculty for their achievements in research?

Mark only one oval.

Extremely well

Very well

Somewhat well

Not so well

Not at all well

12. How well does your institution recognize faculty for their achievements in teaching?

Mark only one oval.

Extremely well

Very well

Somewhat well

Not so well

Not at all well

Course Information

Please answer the following:

13. Which of the following methods of active learning do you incorporate into your teaching?

(Check all that apply)

Check all that apply.

Game-based learning

Peer or team-based learning

Case Studies

Problem- or research-based learning

Use of clickers

Other:

14. What percentage of your students interact with you face-to-face outside of lecture for help (e.g. office hours, tutoring, etc.)?

Mark only one oval.

10% of students or less

10-25% of students

25-50% of students

50-75% of students

75% of students or more

15. What is the approximate average enrollment in your course per semester?

16. What kinds of activities do students complete as part of your course and how frequently?

Mark only one oval per row.

All of the time

Most of the time

Some of the time

Never

Guided reading questions

Chapter quizzes

Lecture guides

Vocabulary/Terminology quizzes

Scenario-based problems

Case studies

Interactive online quizzes

Practice test/exam questions

Worksheets

Concept maps

Writing assignments (informal e.g. short answer questions, paragraph essays)

Writing assignments (formal e.g. lab reports)

17. Of the activities used, when do students complete these activities?

Mark only one oval per row.

Before lecture/lab

During lecture/lab

After lecture/lab

A mix of in-class and out of class

Not applicable

Guided reading questions

Chapter quizzes

Lecture guides

Vocabulary/Terminology quizzes

Scenario-based problems

Case studies

Interactive online quizzes

Practice test/exam questions

Worksheets

Concept maps

Writing assignments (informal e.g. short answer questions, paragraph essays)

Writing assignments (formal e.g. lab reports)

18. How are class activities delivered to students?

Mark only one oval per row.

Online

Mixed (some face-to-face, some online)

Face-to-face

Before lecture/ Pre-lecture activities

During lecture/ In-class activities

After lecture/ Post-lecture activities

19. Is there anything else you would like to add about how class activities are used in your course that are not described above?

20. Do you have any other comments, questions, or concerns you would like to share?

21. Would you be willing to include your course and students in a future study on how various elements of classroom structure impact at-risk student performance?

Mark only one oval.

Yes

No

Maybe

Submission Confirmation

Thank you for submitting your response! Your name will be entered into a drawing for one of three $50 Amazon gift cards. The drawing will take place on October 1st, 2016 and winners will be notified via email.

Appendix C: Follow up Survey

Course Structure and Summative Assessment in Introductory Biology Courses

Please consider the following definitions and explanations when completing the survey:

1. Pre-lesson is before an instructional unit or collection of concepts are taught.

2. Post-lesson is following/immediately after an instructional unit or collection of concept are taught.

3. Lecture period refers to the scheduled class meeting time.

Peer Learning and Course activities

1. How do you define/describe peer learning in your classroom?

2. Please indicate when you use peer learning in your course (check all that apply):

Check all that apply.

Before class

In class

After class

On Line

Face to face

3. Please describe a lower-order cognitive skill question or activity that you have used or currently use in your course:

4. Please describe a higher-order cognitive skill question or activity that you have used or currently use in your course:

Course Structure

The previous survey had asked about different types of activities and assignments delivered in introductory biology courses. Approximately what proportion of your entire course is comprised of:

5. 1. What proportion of your entire course is comprised of online pre-lesson work?

Mark only one oval.

<10%

10-24%

25-49%

50-74%

75-94%

>95%

6. 1a. Please describe these activities.

7. 1b. Do they require higher order thinking skills?

Mark only one oval.

Yes

No

Other:

8. 2. What proportion of your entire course is comprised of online recordings of instruction/lesson?

Mark only one oval.

<10%

10-24%

25-49%

50-74%

75-95%

>95%

9. 2a. Please describe these activities.

10. 2b. Do they require higher order thinking skills?

Mark only one oval.

Yes

No

Other:

11. 3. What proportion of your entire course is comprised of online post-lesson work?

Mark only one oval.

<10%

10-24%

35-49%

50-74%

75-95%

>95%

12. 3a. Please describe these activities.

13. 3b. Do they require higher order thinking skills?

Mark only one oval.

Yes

No

Other:

14. 4. What proportion of your entire course is comprised of Face-to-Face (during lecture period) pre-lesson work?

Mark only one oval.

<10%

10-24%

25-49%

50-74%

75-95%

>95%

15. 4a. Please describe these activities.

16. 4b. Do they require higher order thinking skills?

Mark only one oval.

Yes

No

Other:

17. 5. What proportion of your entire course is comprised of Face-to-Face instruction or lessons?

Mark only one oval.

<10%

10-24%

25-49%

50-74%

75-95%

>95%

18. 5a. Please describe these activities.

19. 5b. Do they require higher order thinking skills?

Mark only one oval.

Yes

No

Other:

20. 6. What proportion of your entire course is comprised of Face-to-Face during lecture period) post-lesson work?

Mark only one oval.

<10%

10-24%

25-49%

50-74%

75-95%

>95%

21. 6a. Please describe these activities.

22. 6b. Do they require higher order thinking skills?

Mark only one oval.

Yes

No

Other:

23. Consider the information you have provided above. Please explain why you have structured your course in this way:

Feedback and Assessments

24. What would you consider the biggest barriers to delivering and/or completing pre-lesson and post-lesson activities in class?

25. How do you provide feedback to students?

26. Do your teaching evaluations (from students and peers) provide meaningful feedback? If so, please provide an example of how you have used this feedback to improve your teaching practice:

27. Consider at-risk students at your institution. What do you consider the biggest challenges these students face in succeeding in an introductory science course?

28. How do you assess student learning and how frequently do you assess your students?

29. Please indicate if you are willing and able to provide de-identified final exam grades. If so, we will work on your behalf with the institutional review board and FERPA offices at your institution to obtain approval.

Mark only one oval.

Yes, I am willing to provide student exam data upon approval from my institution.

No, I do not wish to share student exam data.

Final Exam Information

We would like to evaluate the difficulty and types of questions used to assess students in differently structured introductory courses. If you are willing to provide a copy of your final exam questions, please email those to XXX. We will gladly provide you with a summary of how your exam questions were categorized and classified.

VITA

OLUWASEUN AGBOOLA

Education: East Tennessee State University, Johnson City, Tennessee, USA.

Master of Science, Biology, May 2017

University of Ilorin, Ilorin, Kwara State, Nigeria.

Bachelor of Science, Anatomy, July 2011

Experience: Teaching Assistant for Introductory Organismal Biology labs for Majors at East Tennessee State University. August 2015 - April 2017

Anatomy and Physiology Lecturer at Oyo State School of Nursing, Ibadan, Oyo State, Nigeria. November 2011-November 2012

Presentation: 77th Annual Meeting of the Association of Southeastern Biologist (ASB) in Concord, North Carolina. April 2016 "Improving Student Success in Introductory Biology: The Use of Summative Assessment as an Inclusive Practice."

National Association of Biology Teachers (NABT) Professional Development Conference in Denver, Colorado. November 2016 "Improving Student Success in Introductory Biology: The Use of Summative Assessment as an Inclusive Practice."

Publication: O. Agboola and A. Hiatt (in press 2017). Delivery of Summative Assessment Matters for Improving Student Learning in Introductory Biology. *Journal of College Science Teaching.*

Activity: Member, Shades of Africa - ETSU, 2015 – present

Member, Global Perspective Committee (GPC) in

National Association of Biology Teachers (NABT)

November 2015 – present

Member, ETSU Graduate and Professional Student Association (GPSA)

Chaplain, ETSU Gospel Choir, August 2016 – April 2017