Use of Consistent Formative Assessments to Engage Students in a Second Semester Human Anatomy and Physiology Course

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Abstract

In the United States, there is a demand for registered nurses. To be admitted into the nursing program, students need to complete prerequisite courses such as human anatomy and physiology. Many students find human anatomy and physiology challenging due to the nature of the content. Poor performance in human anatomy and physiology can preclude a student from enrolling in the nursing program. Professors can support students in their learning activities with strategies that can have a positive impact on learning and improve learner outcomes. The objectives of this study are to use consistent formative assessments such as pre-course assessment, course syllabus quiz, reading assignments (pre-learning), in-class activities (during learning), and post-learning activities to engage students in a human anatomy and physiology course. It is important to share these strategies for engaging students with other educators of allied health students. Data were collected on students' performance on pre-course assessment, course syllabus quiz, pre-learning, during learning, and post-learning activities (n=9). Pre-course assessment, course syllabus quiz, and post-learning quizzes were completed on Moodle. Pre-learning reading assignments were completed using McGraw Hill Connect embedded within Moodle. During learning and post-learning activities were completed in the classroom.

The mean data for different forms of formative assessment are pre-course assessment (67.8%), course syllabus quiz (84.4%), pre-learning reading assignments (99%), during learning activities (94.2%), and post-learning activities (78.8%). The data show that consistent formative assessments can be used to engage students in active learning, help them prepare for summative assessments, and impact knowledge with positive learner outcomes. https://doi.org/10.21692/haps.2024.002

Key words: Anatomy, physiology, nursing, formative assessments

Introduction

In the United States, registered nursing is projected to grow at 6% until 2032 (Bureau of Labor Statistics, 2023). Due to the growth and aging population in the United States of America, many students want to go into the nursing profession to become registered nurses. There is a need for colleges and universities to train nurses to meet the supply and demand for nurses. To be admitted into the nursing program, students are required to complete prerequisite courses. Two of the prerequisite courses required are human anatomy and physiology 1 and 2, including their laboratory courses. These are introductory college STEM (science, technology, engineering, mathematics) courses and are referred to as "gatekeeper" courses (Forgey et al., 2020; Gasiewski et al., 2012). In this case, anatomy and physiology courses are a "gatekeeper" into the nursing program.

Human anatomy and physiology courses are designed to help students learn, and understand the structure, function of the human body, and disease conditions. A good knowledge of human anatomy and physiology is important to the nursing profession and other health fields. Many students experience human anatomy and physiology as challenging due to the nature of the course content, which includes vast amounts of content that require mastery and connections to ideas and concepts. When students find a course challenging, it leads to a lack of intrinsic motivation and an inability to create time to study and learn the material at deeper levels (Grachan & Quinn, 2021; Tracy, et al., 2022). In addition, because of the challenges these students experience, they find it difficult to connect the concepts to real-world situations (Grachan & Quinn, 2021). The passing rate for human anatomy and physiology with a grade of C or better is 50% (Forgey et al., 2020). Poor performance in human anatomy and physiology courses often precludes students from enrolling in the nursing program.

There are several reasons students perform poorly in human anatomy and physiology courses. A study conducted in South Africa showed that ineffective teaching strategies, lack of after-class review sessions or tutoring opportunities, and failure to devote enough study time were among the contributing factors (Mhlongo et al., 2020). In addition, the

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professor's attitude, instructional strategies, passion, content knowledge, intrinsic motivation, and attitude of the students also impact academic engagement (Gasiewski et al., 2012). There is diversity in the backgrounds of students enrolled in human anatomy and physiology courses (Forgey et al., 2020). Some students have knowledge gaps coming into college (Forgey et al., 2020). There are students with a long gap between the time they graduated from high school and when they enrolled to take human anatomy and physiology, and students coming into the pre-nursing program without a science background. There are also students without a basic biology prerequisite course in college prior to human anatomy and physiology courses (Forgey et al., 2020). However as evidenced in the research of (Forgey et al., 2020), taking a prerequisite course may not predict success in human anatomy and physiology. Some students are parents, full-time employees, caregivers to aging parents, and have limited time to devote to studying the materials. Many factors may contribute to poor performance in human anatomy and physiology courses.

It is the responsibility of human anatomy and physiology professors to understand the diversity of students in their classrooms so that the professors can provide positive learning environments that cater to the unique needs of each student in their classrooms. The professors remain an important element in engaging students in their learning activities (Brown et al., 2018; Gasiewski et al., 2012; Tracy et al., 2022). Professors must be intentional in choosing activities that deeply engage students in their learning experiences. Providing opportunities for students to engage with the content increases the probability of a positive learning outcome and high course content engagement is associated with high academic achievement (Brown et al., 2018; Gasiewski et al., 2012). Students will benefit from learning activities that interest and engage them in the classroom for deeper learning of human anatomy and physiology (Brown et al., 2018).

A strategy to engage students in their learning activities is the use of consistent formative assessments (Dimple, 2023). A formative assessment is an evaluation that is done during the learning process to inform both the students and the professor on learning outcomes and knowledge gaps (Chiappetta & Koballa, 2014; Dimple, 2023; Evans et al., 2014). Formative assessment can be done before the learning process (Chiappetta & Koballa, 2014), during the learning process (Chiappetta & Koballa, 2014; Dimple, 2023), and at the end of the learning process (Chiappetta & Koballa, 2014). Students are provided opportunities for pre-class activities such as reading assignments, research, and worksheets. Students can also be evaluated for their understanding of a concept during the learning process and post learning such as group presentations, modeling of learning, short response prompts, quizzes, question, and answer sessions. Throughout the learning process, students are consistently being held accountable for their learning and engagement with the content. Students get immediate and valuable feedback on their learning outcomes (Dimple, 2023; Kulasegaram & Rangachari; 2018). Formative assessment also provides the teacher feedback on what students know and the knowledge gaps to enable the teacher to plan for future instructions (Chiappetta & Koballa, 2014; Dimple, 2023; Evans et al., 2014).

Continuous formative assessments spread across the span of the course can be used to engage students (Evans et al., 2014). Students are likely to do well in a course when multiple opportunities are provided to review, practice, and master the materials presented in class. For formative assessments to be effective, there should be learning objectives (Dimple, 2023; Kulasegaram & Rangachari, 2018) to help the professors and students evaluate learner outcomes (Kulasegaram & Rangachari, 2018). The goals of formative assessments are to help students master the content, prepare for summative assessments, and grow in the content knowledge for future applications (Dimple, 2023).

The objectives of this study are to use consistent formative assessments (pre-course assessment, course syllabus quiz, reading assignments (pre-learning), in-class activities (during learning), and post-learning activities to engage students in a human anatomy and physiology course to improve learner outcomes and the success rate. In addition, share my strategies for engaging students with other educators of allied health students.

Methods

This study was conducted in a second-semester human anatomy and physiology course during the spring semester. The course was for 16 weeks with three-contact hours of lecture per week. In addition to the three lecture hours, there is a separate human anatomy and physiology laboratory course. Data were only collected for the lecture portion of the course. Each student had completed a first-semester human anatomy and physiology course. The course started with eleven students (n=11). However, only nine (n=9) stayed until the end of the course. Data for the two students who dropped the course were not included in this research. Due to the small sample size, data for gender and age were not included in this study. This study used a learning management system (Moodle) for the quiz-based activities and McGraw Hill Connect embedded within Moodle for the reading assignments. During learning and post-learning activities were completed in the classroom. Pre-learning reading assignments and course syllabus quiz were completed at home by the students. Students brought their laptops to the classroom for each course meeting.

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At the beginning of the semester, students were pre-assessed on their knowledge of human anatomy and physiology 1. The preassessment had 10 multiple-choice questions from concepts covered in human anatomy and physiology 1. The concepts tested on the pre-course assessment include homeostasis, levels of biological organization, properties of living things, cellular transport, functions of epithelial tissue, cell connections and barrier, tissue damage and inflammation, layers of the epidermis, osteoclast activity, and oxygen transporter. These are concepts mostly covered in human anatomy and physiology 1. Students are expected to come into human anatomy and physiology 2 with good knowledge of these concepts. The pre-course assessment was administered on Moodle but completed in the classroom with the use of a laptop. Students were informed that the pre-course assessment did not count against them for a grade.

The course syllabus was reviewed with the students at the first course meeting after which the students completed a course syllabus quiz on Moodle. The quiz addressed course policies, university policies, professor contact information, office hours, due dates for exams and assignments, and general questions that students may need to be addressed. The quiz contained 10 questions that ranged from multiple choice, true/false, fill in the blanks, and short responses.

Reading assignments were completed using McGraw Hill Connect embedded within Moodle. Students were assigned reading assignments throughout the semester. Reading assignments were assigned based on the chapter/concepts to be discussed for the week of the assignment. Students were required to spend 3-4 hours per week on reading assignments. As they completed each reading assignment, students responded to questions based on the concepts to evaluate their reading comprehension of the concepts. The first reading assignment was assigned after the first course meeting. The last reading assignment was completed before the final exam week. Students were not assigned reading assignments during exam weeks and spring break. Each reading assignment constituted a pre-learning activity for the students. Students were given credit for completing each reading assignment. All the reading assignment assessments were auto-graded for correctness with opportunities to correct mistakes at no penalty. A total of seven graded reading assignments were used for this course.

There were several scheduled in-class activities to promote active learning and engagement in the classroom (during learning and post-learning activities). Group work, worksheets, modeling of learning, "turn and talk" research and presentation, short response prompts, quizzes, etc., were consistently used to evaluate students learning. For the group work, students were assigned to groups based on proximity. Each group was given a topic with specific learning objectives. Students researched their topics, discussed among themselves through peer teaching, and presented their understanding of the concepts to the class. Opportunities were also provided for students in other groups to ask questions to the presenting students.

Seven in-class activities were graded for correctness with opportunities for students to correct their mistakes. Two post-learning quizzes were graded for correctness. Post-learning quizzes were completed on Moodle. Some of the activities used during learning and post-learning activities were also listed as forms of formative assessment (Dimple, 2023). Formative assessments should be balanced with summative assessments to get accurate information on a student's academic ability (Dimple, 2023).

The following topics were covered for this course: cardiovascular system (blood, heart, blood vessels, and circulation), lymphatic system and immunity, respiratory system, digestive system, nutrition, metabolism, and temperature regulation, urinary system, endocrine system, reproductive system, development, growth, aging, and genetics. The activities used for this research cut across these topics. Formative assessments accounted for 26.52% of the final grade in the course used for this study. The different forms of formative assessment, contributions to the final course grade, sample learning objectives, sample questions, or prompts are shown in Table 1.

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Formative Assessments	Contributions to final grade	Learning Objectives aligned to assessment	Sample Prompts Questions or Activities
Course syllabus quiz	2.54%	Students will demonstrate mastery of important information needed to be successful in the course, such as course objectives, course policies, due date, and grade distribution.	Have you reviewed the course syllabus? What is the attendance policy for this course? Are due dates posted on the course syllabus/model? What are your questions on the course syllabus?
Pre-course assessment	0%	Students will apply knowledge from human anatomy and physiology	Which of the following is consistent with homeostasis? The changes an organism undergoes through time is _____. Glucose is transported across the plasma membrane by _____ process.
Pre-learning activities	11.56%	Students will be able to respond accurately to concepts and ideas presented in selected chapters of the textbook.	Connect reading assignments and evaluation of reading comprehension. Students are required to come into the classroom ready to ask questions and discuss learned concepts. Warm up activities.
During learning activities	9.3%	Students will demonstrate mastery of concepts discussed in the classroom. Students will model learning in the classroom. Students will learn in groups, turn, and talk to each other on course concepts.	Group work/presentation on assigned topics. Example, discuss the roles of the following organs in immunity: lymphatic tonsils, lymph nodes, thymus gland, and spleen. "Turn and talk" activity, and worksheets.
Post learning activities	3.12%	Students will show mastery of learned concepts.	Quizzes, summaries, question and answer sessions

Table 1. *Forms of formative assessment aligned to sample learning objectives and prompts or questions.*

Results

The summary data for the pre-course assessment, course syllabus quiz, pre-learning activities, during-learning activities, and post-learning activities are shown in (Table 2).

Table 2 shows the maximum score, minimum score, standard deviation, mean, and 95% confidence interval (CI) of the mean for each of the formative assessments used in this study. Error bars in Figure 1 represent ± 95% CI of each mean for the forms of formative assessment.

Types of formative assessment	Pre-course assessment	Syllabus quiz	Pre-learning reading assignments	During learning activities	Post-learning activities
Maximum total scores (%)	90	100	100	98	100
Minimum total scores (%)	50	0	92.96	78	50
Means (%)	67.78	84.44	99.11	94.22	78.89
Standard deviations	13.02	31.86	2.33	6.89	13.64
95% Confidence Intervals	8.50	20.82	1.52	4.50	8.91

Table 2. *Summary data of students' performance on the different forms of formative assessment.*

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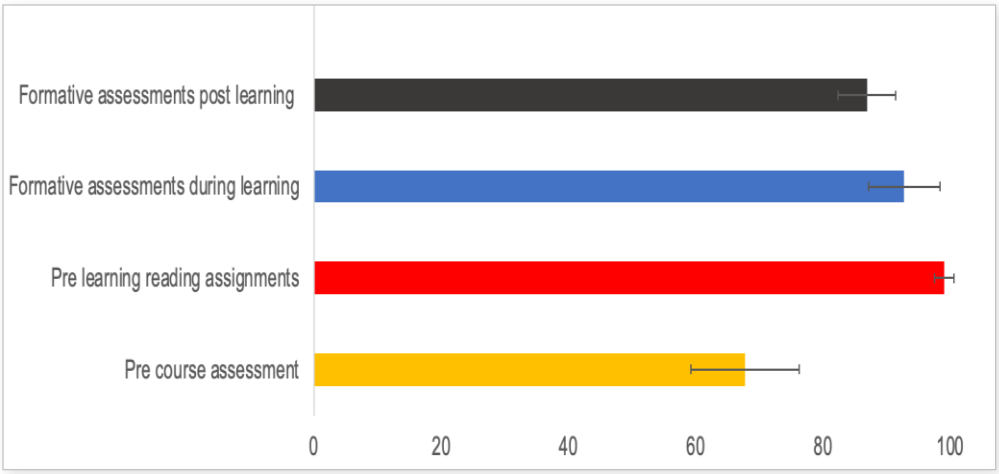

Figure 1. *The mean performance of students in the different forms of formative assessment ± 95% CI (n=9).*

The class mean for the pre-course assessment is 67.8% (Table 2; Figure 1). For the individual items on the quiz, students who gave correct responses were in the following order: 100% for levels of biological organization and functions of epithelial tissue; 89% for homeostasis and osteoclast activity; 78% for layers of the epidermis and oxygen transporter; 67% for cell connections; 33% for property of living things, and 22% for tissue damage and inflammation and cellular transport (Figure 2).

Figure 2. *The percentage of students who gave correct responses in the pre-course assessment (n=9).*

The mean score for the course syllabus quiz is 84.4% (Table 2; Figure 1). The participation rate for the reading assignments (pre-learning activities) is 100% and the mean score is 99% (Table 2; Figure 1). The mean score for the during learning activities is 94.2% (Table 2; Figure 1). The mean score for post-learning activities is 78.8% (Table 2; Figure 1).

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Discussion

Pre-Course Assessment

The data for the pre-course assessment showed that most students performed well in levels of biological organization, functions of epithelial tissue, homeostasis, osteoclast activity, layers of the epidermis, and oxygen transporter (Figure 2). However, there were still knowledge gaps in some concepts that needed to be accommodated in future instructions. Students struggled with the properties of living things, cellular transport, and inflammation. According to Chiappetta & Koballa (2014), preassessment is diagnostic and serves to determine what students already know, so that educators can meet the learning needs of students through instructions. The preassessment provided the students and professor with immediate feedback and helped the professor plan for future instructions (Kulasegaram & Rangachari, 2018). Lazarowitz & Lieb (2006), used preassessment in a biology course to evaluate students' basic knowledge in the respiratory system. Lazarowitz & Lieb (2006) found that students had misconceptions and basic knowledge gaps on the respiratory system. This study also revealed knowledge gaps and misconceptions in basic knowledge in some of the concepts evaluated during the preassessment.

Concepts such as properties of living things, cellular transport, and inflammation are parts of Human Anatomy and Physiology 1 curriculum of most colleges and universities. Students are expected to come into Human Anatomy and Physiology 2 with a basic understanding of the properties of living things, cellular transport, and inflammation. Knowledge gaps or misconceptions could be attributed to students' learning difficulties (Lazarowitz & Lieb, 2006). Learning difficulties could be explained by differences in academic backgrounds, abilities, cognitive stages, and learning styles (Gasiewski et al., 2012; Lazarowitz & Lieb, 2006). The inability to integrate learning across related concepts can lead to knowledge gaps and misconceptions. It is the role of the professor to understand the backgrounds of students in the classroom, plan, and design instructions to accommodate diverse learners.

Preassessment when combined with feedback has a positive impact on students learning and performance (Kulasegaram & Rangachari, 2018; Ivanistkaya et al., 2008). The pre-course assessment provided the professor with baseline knowledge of the students coming into Human Anatomy and Physiology 2. It also helped to identify and address misconceptions. It also provided students with immediate feedback and review opportunities for poorly mastered concepts. Providing feedback to students promotes student engagement and learning (Gasiewski et al., 2012; Kulasegaram & Rangachari, 2018).

Syllabus Quiz

The data for the syllabus quiz is shown in (Table 2; Figure 1). One student did not take the quiz and was assigned a 0 after the student failed to use a makeup opportunity. The course syllabus is a contract between the students and the professor. In this study, students were provided the opportunity to take a course syllabus quiz to understand the course requirements, university and course policies, and due dates. They were also provided the opportunity to ask clarifying questions during the quiz. When students ask questions and get answers to their questions, they engage more with the content and build a relationship with the professor (Gasiewski et al., 2012). All the students who took the syllabus quiz passed with scores of 90% and above (Figure 1, Table 2). Raymark & Connor-Greene (2002), found that a take-home syllabus quiz improved students' understanding of course policies and professor expectations. It provided students with opportunities to understand the due dates for exams and assignments, expectations, course content, grading scale, course, and university policies. Having students review and take a quiz on the course syllabus sets them up for success in the Human Anatomy and Physiology course.

Pre-learning Activities

The data for the pre-learning reading activities are shown in (Table 2; Figure 1). The reading assignments were engaging and provided opportunities for students to pre-read the text, annotate specific content, respond to prompts generated, review, get immediate feedback, and write down their questions to be discussed during learning activities. When students are provided opportunities to ask questions, their engagement and learning are improved (Gasiewski et al., 2012). One hundred percent of the students participated in the reading assignments and students received grades for their completion of the assignments. The use of reading assignments as formative assessments can be motivating for students. According to Kerr and Frese (2017), lack of motivation is one of the reasons college students fail to complete course readings. Reading assignments completion among undergraduate students is low (Kerr & Frese, St Clair-Thompson et al., 2017), ranging between 20-30% (Kerr & Frese, 2017). In this study, 100% of the students completed the reading assignments as they were tied to the final course grade. Students are more likely to complete reading assignments when they earn points for the reading and points earned become part of the course grade. Findings from St Clair-Thompson et al. (2017) also showed that students would complete reading assignments if they were part of the course requirements. Students should be provided opportunities for minimally graded assignments and should earn points for completed work (Hanstedt, 2020). Combining in-class activities with a web-based activity can increase students' engagement with the course content (Gasiewski et al., 2012).

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Learning Activities

The data for the in-class learning activities for the students are shown in (Table 2; Figure 1). Formative assessments of students during learning redirect the focus to "what was learned" rather than "what was taught" (Dimple, 2023). This study utilized a variety of formative assessment strategies, which included formative written assessments. According to Carter & Prevost (2023), short response prompts provide opportunities for students to think deeply and construct responses that connect to different concepts. Formative written assessments help students integrate learning within concepts and across concepts. Formative assessments when aligned with the learning objectives are effective (Kulasegaram & Rangachari, 2018; Dimple, 2023) in helping students engage and learn at higher levels. In this study, the formative assessments were aligned with the learning objectives and helped students to learn at higher levels. Students received immediate feedback on their learning and were provided opportunities to make corrections to learn the concepts at a deeper level. The professor has a role in engaging students during the learning process to enable students to achieve at higher levels.

Post Learning Activities

The data for the post-learning activities are shown in (Table 2; Figure 1). For this course, the last 10-15 minutes of class were used to summarize what was learned and provide opportunities for students to demonstrate mastery of the concepts, ask questions, and correct misconceptions. During post-learning activities, the focus should be "what was learned" rather than "what was taught' (Dimple, 2023). In this study, exit slips, quizzes, and "turn and talk" to your partner were some of the post-learning activities. These instructional approaches support students learning in the classroom (Gasiewski et al., 2012). Based on the data of students' performance on the post-learning activities (Table 2; Figure 1), students were engaged on average in their learning activities. Students are more likely to engage in their learning activities when the professor consistently provides opportunities for students to demonstrate learning through formative assessments. When students know that each day in the classroom counts toward their final grade that is motivational for them. Through formative assessments, students get immediate feedback and understand when additional efforts are required to enhance grades (Jiang, 2023).

When students learn and do well academically, they are happy and provide positive feedback to the professor. This is evidenced by feedback from the students.

According to student A,

"I just looked at my grades and I am so happy I passed my first Exam! I was so scared I was going to get a bad grade! I love your way of teaching! I have learned so much this semester than I have the whole time I have been in school honestly! I retain a lot the things you teach and I am very proud of myself! Thank you for being such a good teacher!"

According to student B,

"Professor made Anatomy 2 so engaging and I felt like I was really challenged throughout this course. I loved taking this with her because I learned so much from this class!"

The motivation to engage with the course content and learn at a deeper level is driven by the reasons the students are taking the course (Gasiewski et al., 2012). Gasiewski et al. (2012) showed that students in the premed program were more engaged/ motivated than students taking a STEM course to meet a graduation requirement, regardless of the reason why a student is taking a course. The professor has a role to play in providing an environment where students can learn at higher levels, engage with the course content, and achieve at higher levels. The use of consistent formative assessments during instructions creates an active learning environment and supports students' engagement as shown in this study.

Limitations

The author acknowledges that large class size, physical structure, and available time can impact the ability to use consistent formative assessments in the classroom (Kulasegaram & Rangachari, 2018). In addition, course attendance issues, and resource gaps such as access to technology (computers, learning management systems such as Moodle, and digital learning platforms such as McGraw Hill Connect) can limit the use of some of the strategies used in this study.

Conclusions

Formative assessments provide immediate feedback to students and the professor on what the students have mastered, knowledge gaps, opportunities to correct misconceptions, and additional learning opportunities. Formative assessments should be frequent in difficult courses such as Human Anatomy and Physiology. Providing students diversity in formative assessments helps evaluate students understanding of the relationship between structure and function. Knowledge gained during formative assessments will help the students prepare for summative assessments, support learning in the classroom, and prepare the students for future instructions.

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Feedback from the students shows that students were engaged in the course and benefited from consistent formative assessments. Students engaged with the content, and learned collaboratively, cooperatively, and independently. Students were provided the opportunities for them to grow in their knowledge; while acquiring life skills such as the ability to speak in front of an audience, cooperate, and function as a team member. Several factors affect students' performance in the classroom, and the professor and students have roles to play in achieving academic success for the students in the classroom (Gasiewski et al., 2012; Tracy et al., 2022). Throughout this study, I provided a positive learning environment that supported students learning using consistent formative assessments, feedback, correction of misconceptions, and the ability to learn at deeper levels. Students were able to reflect on their learning, embrace learning, construct an understanding of challenging concepts, and develop a "growth mindset." In this course, 100% of the students passed with a grade of C and above. Strategies used in this research can also be applied to other courses to improve learner outcomes.

In the future, formative writing assessments, culturally responsive projects, and project-based learning will be largely employed to engage students and help them show mastery of concepts discussed in the course.

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