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A PRAGMATIC APPROACH TO FLIPPING THE CLASSROOM FOR 170 MEDICAL STUDENTS

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Employing a flipped classroom is an excellent way to increase student engagement, integrate material, and elevate learning from memorization to application. This case highlights the design, development, implementation and evaluation of a flipped classroom approach for a large group of medical students at a US military medical school. We discuss the specific learning problems and challenges that formed the team and rationale for the design. We then describe the thought process used to develop the flipped classroom application, including format, content and implementation of digital learning tools. Finally, we reflect on findings from implementation of the design in an 8-week Neuroscience module, including improvements in student-faculty interaction, student engagement, learning climate and unexpected benefits.

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INTRODUCTION

Medical knowledge is growing at exponential rates (Densen, 2011). This ever-increasing growth of medical knowledge often results in increased time delivering content via lectures or assigned reading. Prioritizing content delivery can often be at the expense of providing students with opportunities to integrate material across disciplines, synthesize material, or apply the material to clinical contexts. The shift to online learning because of the COVID pandemic has only exacerbated this challenge (Papapanou et al., 2021).

One method for optimizing student-faculty time for higher-level educational activities is the "flipped classroom." The Flipped Learning Network (2014) proposed a model in which students gain first-exposure learning prior to class and focus on the processing part of learning (synthesizing, analyzing, problem-solving, etc.) in class. While this model has been shown to be successful in a wide variety of contexts (Foertsch et al., 2002) - including undergraduate medical education (Ramnanan & Pound, 2017; Grant et al., 2021), implementing such a program can be challenging (Foertsch et al., 2002; Prunuske et al., 2012). Determining what content the students should review in preparation for the classroom experience, how to balance independent study with contact hours, integrating content across multiple specialties and departments, and finding methods for multiple faculty members to engage the students at the same time all represent barriers to implementing a flipped learning experience in an undergraduate medical education setting.

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CONTEXT

Overview of the USU School of Medicine

The Uniformed Services University (USU) School of Medicine is the only medical school in the United States that is operated by the Department of Defense. The school's mission is to support the US military by developing world-class clinicians who will lead military health care. The four-year program accepts roughly 170 students per class. The pre-clerkship curriculum, like at many other medical schools, is divided into organ-based modules integrating basic sciences, clinical sciences, and anatomy. Students are in the pre-clerkship phase for a total of 16 months. The clinical phase includes nine required clerkship experiences with durations of 4-10 weeks, elective rotations, and opportunities to engage in research projects.

Students range in age from 22-40 years, with 46% being women and 39% being from under-represented minorities. Despite being a military medical school, approximately 60% of students in the school of medicine have no prior military service. Approximately 170 students attend the USU School of Medicine every year.

The pre-clerkship period comprises the first 16 months of the medical curriculum and consists of seven summative-graded instructional blocks or modules. The modules range in duration from seven to nine weeks and include an introductory Foundation in Medicine module, five organ system-based modules (Musculoskeletal, Cardio-Pulmonary-Renal, Neuroscience & Behavior, Gastrointestinal & Hepatobiliary, and Endocrine & Reproductive), and a final module on Multi-systems & Complex Diseases. Each pre-clerkship module integrates basic science concepts with content related to clinical reasoning and clinical skills, such that students acquire knowledge of anatomy, physiology, pathology, microbiology, and pharmacology and learn to apply it to clinical disorders referable to each organ system. The grading scale is Pass/Fail for the Foundation in Medicine module and Honors/Pass/Fail for the remaining six modules. Students must achieve a grade of Pass or Honors in all seven of the pre-clerkship modules in order to advance to the clerkship period of the curriculum. Embedded throughout the pre-clerkship phase is a USU-unique curriculum where students learn to not only become physicians but to become military physicians.

Each module is led by a pair of co-directors, one a clinician and the other a basic scientist, who are appointed by the Office of Medical Education. The module directors are responsible for the design, sequencing, and implementation of the educational activities within their module, including assessments, and for assigning final grades to the students. The module directors work with designated subject-specific course directors, who are tasked with creating educational content within their discipline that aligns with the overarching goals and objectives of the module. Each course director is chosen by the chair of the basic science or clinical department responsible for the specific content area. For example, in the neuroscience & behavior module, a total of 15-course directors contribute content in areas such as anatomy, pharmacology, pathology, microbiology, clinical neurology, psychiatry, radiology, etc. The course directors are responsible for recruiting faculty members with the appropriate expertise, usually members of the course director's academic department, to teach in the educational activities. Therefore, a given module will typically have anywhere from 60 to 100 participating faculty members from multiple departments, who deliver lectures, guide laboratory sessions, facilitate small group discussions, and provide clinical skills training.

Overview of the Neuroscience & Behavior Module

The neuroscience & behavior module is the fourth pre-clerkship module at USU. This module introduces anatomy, physiology, pathology, and related clinical diagnoses and treatments specific to Neurology, Psychiatry, and disorders of the head, neck, and spine. Spanning eight weeks, the course includes approximately 180 contact hours, half of which are lectures, while the remainder consists of small group discussions, hands-on laboratory sessions, physiology demonstrations, and cadaveric dissections. The course includes content from 10 different departments, with the majority of the content coming from the Departments of Anatomy, Physiology, Genetics, Psychiatry, and Neurology. Some Departments, such as Biostatistics and Epidemiology, have only three hours of content in the entire module. Representing all ten departments, over ninety faculty teach in the module. Some faculty are full-time clinicians at our affiliated teaching hospitals, while most others are full-time clinician educators or basic science researchers at USU.

Overview of Previous Innovations in the Neuroscience & Behavior Module

Historically, all the lectures in the pre-clerkship curriculum at USU were delivered in person. As at many other institutions, an automated lecture capture system was used to generate lecture recordings that the students could view on their own at a later time. Lecture attendance was not mandatory, as the Liaison Committee on Medical Education (LCME) guidelines limit the use of mandatory sessions in medical education (LCME, 2021). This traditional way of presenting lecture content is associated with a number of disadvantages. For one, lecture attendance was always low (typically, only 5% of the class attended in-person neuroscience & behavior module lectures). Also, students who chose to learn from the recorded lectures had to wait for the recording to be processed and uploaded, which could be anywhere from an hour after the presentation ended to two days later. Technical problems with the recorded lectures were common, including poor

audio quality, missing the beginning or end of the lecture, or failure to record altogether. Because of these problems, many students gave up on using the lecture recordings and turned to outside resources to try to meet the learning objectives.

To address these problems, in 2019, the module directors decided to utilize pre-recorded lecture videos in place of in-person lectures in the neuroscience & behavior module. Using the professional recording studio available through the Education & Technology Innovation (ETI) Support Office at USU and following best practices (Kurzweil et al., 2020), each of the neuroscience & behavior module faculty members pre-recorded their lecture in the months leading up to the start of the module. The recordings were of much higher audio and video quality than those previously recorded with the lecture capture system and included a video of the speaker delivering the presentation in an inset. The faculty also embedded multiple choice "knowledge-check" questions into the recordings so that the students could formatively assess their mastery of the lecture content. The recordings were made available to the students to watch asynchronously, along with a suggested schedule of when, and in which order to watch the lectures.

Without any compromise in performance, this innovation had a number of positive outcomes, including increased student engagement with the recorded lecture content, increased control over time management on the part of the students, improved flexibility for scheduling the many synchronous laboratory and small group sessions in the module, and better opportunities for peer review of lecture quality and content prior to presenting them to the students. Additionally, students expressed a high level of satisfaction with the pre-recorded lectures - requesting that they be used in other modules.

Despite these successful learning outcomes, the module directors, faculty, school leadership, and students voiced concerns about possible adverse effects related to reduced student-faculty and student-student interactions. These concerns are fully described below, along with innovative use of the flipped-classroom model to address them.

PROBLEM

Decreased Interaction with Faculty

Research has shown that faculty perceptions of online courses have generally been mixed with reported challenges related to student engagement, student evaluation of teaching, delivery of content, comfort with technology, and cost (Ruth, 2018; Ward et al., 2010; Maguire, 2005). Faculty at USU were accustomed to traditional learning models where students and instructors are present in the classroom at the same time and shared some of these same concerns. These concerns included the inability to confirm that information was being clearly delivered and understood and reduced knowledge of students on a personal level. This concern was particularly strong among faculty whose subject matter was presented exclusively in lecture format as compared to other faculty who would retain the ability to interact with students in the laboratory or small group settings. Students were encouraged to email faculty with questions, however, despite an increase in an email to faculty, the module directors and school leadership still worried about decreased explicit engagement at the class level.

Decreased Ability to Engage Students

Student engagement with each other and with faculty members has been cited as a concern in the online learning environment (Gonzalez & Moore, 2020; Ward et al., 2010). However, the literature suggests that faculty development in best practices to increase student engagement can prove successful results (Leslie, 2020). Faculty at USU university had concerns with the concept of pre-recorded lectures and perceived overall reduced engagement with the students. Faculty cited the inability to make eye contact with students, read body language, engage in conversation, and answer questions in real-time as potential limitations (Allen & Seaman, 2012). Additionally, there was limited ability to give feedback to individual students or the class. Faculty also had concerns about the decreased ability to re-teach topics that students may have been struggling with. In a traditional classroom setting, students have the opportunity to ask questions in realtime for clarification or to further knowledge. Students could also stay behind after the lecture was over to engage with the faculty member. Some faculty considered these opportunities lost with the use of pre-recorded lectures and videos. Traditional classrooms may have the added benefit of increasing social interaction between students and creating a sense of community, a benefit potentially lacking with the use of pre-recorded lectures.

Compromised Learning Climate

Another problem associated with moving much of the material online was the loss of our learning climate. Neuroscience has a reputation for being one of the most difficult topics in medical education (Tieniber & Readdy, 2016), while Psychiatry carries a great deal of stigma that can interfere with learning objectives (Janoušková et al., 2017). The module directors and faculty had combated these concerns in previous years through the establishment of a positive and safe learning climate (Skeff et al., 1992). Moving much of the curricular content online had the potential of leaving the students feeling isolated and unsupported - something student leaders voiced before even starting the module. Such a compromise could decrease student satisfaction and, more importantly, performance.

Develop a Community of Learners

The final problem the module directors wanted to tackle was the lack of a learning community in the module. With the move to online learning for almost half of the content, students appeared to be missing out on the benefits of learning together. Students who are involved in learning communities appear to learn better and have improved perceptions of learning (Rosenbaum et al., 2007; Cruess et al., 2018; Moser et al., 2015; Champaloux & Keeley, 2016) and this benefit was missing from the redesigned module. The reason students have been shown to have improved educational outcomes in a learning community stems from social learning theory (Bandura, 1971). When learners are able to observe the actions and behaviors of each other during a learning activity in a safe environment, it supports attention and retention of content while increasing motivation to learn. This concern was echoed by student leaders, who noted that they did not want to give up the camaraderie to which they were accustomed.

DESIGN CONSIDERATIONS

Additional Priorities

In addition to tackling the problems outlined above, the module directors also wanted to integrate content from different courses for the students. The module's schedule established temporal coordination (Harden, 2000). A lecture on the anatomy of the spinal canal would immediately proceed with a lecture on the physiology of the facets, followed by a lecture on the pathology of herniation, followed by a lecture on the radiology of such injuries, and then culminating in lectures from the department of Neurology on the treatment of such conditions and a lecture from pharmacology on the treatment of related neuropathic pain. While this temporal coordination provided the most basic scaffold for the learners, it did not integrate the content together into a cohesive, multidisciplinary understanding (Harden, 2000).

The module directors also wanted the students to apply the knowledge they had learned that week to clinical practice. This would require the solution to be more than just a review, but a clinical application that relied on case-based learning (Burgess et al., 2021). Pre-clerkship lectures are typically focused on the basic science behind medicine and thus often struggle to achieve clinical relevance unless the content is explicitly connected to clinical examples. The solution needed to provide a means for students to apply the week's knowledge to a series of clinical cases.

In addition to applying the students' knowledge to clinical cases, the module directors also wanted the students to consider military aspects of clinical care. This included simple aspects like the service, rank, and job of service members to complicated military, cultural phenomena (Meyer & Wynn, 2018). Military medicine also demands consideration of mission impact and population health, so the module directors worked diligently to ensure our solution referenced these aspects of care.

In previous years, the module directors and faculty found that students often struggled to demonstrate their knowledge of vignette-style questions. As opposed to the questions commonly found in undergraduate education that directly ask a question and provide multiple options, in undergraduate medical education, students often have to read a clinical vignette and answer a question based on the information found in the vignette. Navigating such questions can be challenging, and students who may appear to have mastery when asked about the content directly can struggle to succeed in a vignette-style examination. As such, another goal was to provide students with explicit guidance and repeated opportunities to practice demonstrating their knowledge via vignette-style questions.

Since the students were watching lectures online, frequently in isolation, for much of the week and then only gathering in small groups for interactive instruction, the module directors wanted to provide an opportunity to check in with the entire class. This would provide an opportunity to review the content covered in the previous week and to introduce the material scheduled for the following week. Taking the time to orient the students would help reduce missed assignments and assist the students in planning their time effectively. It would also serve as a sensitizing agent - priming the students for the material to come and helping them see the links across multiple weeks of content. Lastly, it would provide an opportunity to normalize that neuroscience is difficult. Reviewing average student performance on quizzes from the week would help students see that they were not alone in their struggle to master extremely complicated concepts.

The final additional priority was a desire for the students to learn to see each other as sources of information. Students learning in isolation would not be able to observe the strategies and approaches of other students, potentially limiting their awareness of how to be successful in the module (Bandura, 1971). The module directors wanted to build such a community of learners that would help each other excel and challenge each other in their thinking.

Challenges

To address concerns from faculty about reduced interaction, student engagement, and the desire to establish a community of learning for the students, the module directors proposed implementing online review sessions that would apply the material to clinical scenarios. While this solution appeared promising at first glance, multiple challenges quickly emerged. First and foremost: engagement. How could a single online session effectively engage 180 students while also allowing each faculty member to engage

one-on-one with students and allow students to engage with each other? Attempting to have an online discussion with such a large group appeared unmanageable.

In addition to determining how to deliver these sessions, selecting what content should be covered during these review sessions presented another challenge. The neuroscience & behavior module is dense. Each week is crammed with critical content that students must know to be competent physicians. Given LCME restrictions (LCME, 2021), if the mandatory review sessions were to be weekly, they could only be ~90 minutes in length. This would make it a challenge to review all the material - especially if the review sessions were to employ clinical scenarios. It would certainly leave little time for the faculty to review their content from the week, let alone allow the students to interact with each other. If the review sessions were optional, they could be longer and cover more material, but this would likely reduce attendance and participation.

Another challenge identified during the planning process was determining how to develop the clinical cases that would integrate content from multiple departments. How could a single clinical vignette be employed for multiple questions from different lectures? This also led to challenges regarding who would create the vignette, the questions and determine what content areas were relevant to the answer. Employing these cases then highlighted a final challenge: how to assess 180 students' ability to apply their knowledge to clinical scenarios in real time.

One solution to navigate these challenges while still resolving these key problems and to emphasize the module's priorities was the use of a flipped classroom.

DESIGNING THE INNOVATION

Use a Flipped Classroom Approach

The flipped classroom approach to learning has been employed in various educational venues for many years. This method of teaching is rooted in the concepts of the Zone of Proximal Development (Vygotsky, 1978) and the 'More Knowledgeable Other' (Doolittle, 1995) where the student discovers what they can learn on their own and where they need guidance to achieve a higher level of understanding (Vygotsky, 1978). Regardless of the venue, the flipped classroom has two essential elements; the first is assigning students pre-class content that is generally foundational. Second, students come to class for face-to-face learning, where they are able to apply what they have learned through reflections, small group discussions, case-based learning, or team-based activities. Foundational material includes book chapters, articles, PowerPoint presentations, or pre-recorded video lectures. This inverted classroom approach enables students to review the content at their own pace and then come prepared to class with questions.

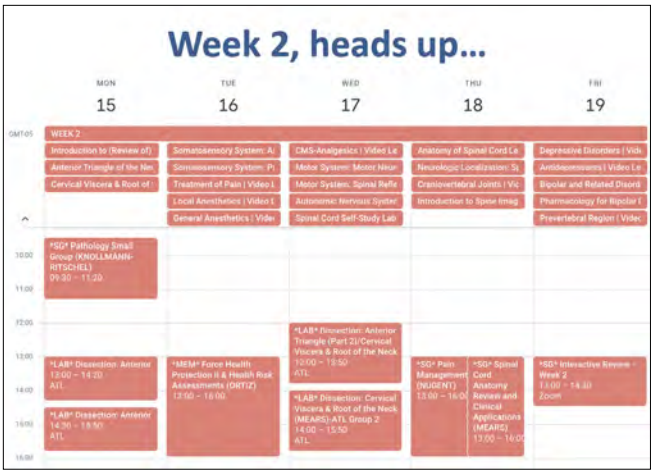

FIGURE 1. Overview of a single week in the Module.

The flipped classroom may be associated with more active learning and may promote higher-order thinking (Chen et al., 2017). Despite having some challenges (Persky & McLaughlin, 2018; Gillette et al., 2018), the flipped classroom approach may lead to improved learning and improved student perceptions of learning (Poon, 2013; McLaughlin et al., 2014; Hurtubise et al., 2015; Kraut et al., 2019; Hew & Lo, 2018; Graham et al., 2019).

In the neuroscience and behavior module, students were expected to watch pre-recorded video lectures throughout the week. A calendar example of how to incorporate these weekly lectures into their schedule was provided (see Figure 1), but students were empowered to watch the videos in a way that worked for them. At the end of each week, students were required to participate in what was termed Flipped Fridays.

Cover Only the Content from That Week

To keep the cognitive load manageable for the students, each Flipped Friday covered only the content that was presented in the current week's video lectures (see Figure 1). In this way, students had the opportunity to review and apply the information shortly after learning it, and the only preparation required prior to the sessions was to watch the assigned videos for the week. By scheduling Flipped Fridays as the final learning activity of the week, students could use the weekend to revisit the material to fill any knowledge gaps identified during the review.

Acknowledge the Content from the Week

In order to ensure the flipped sessions were immediately and explicitly connected to the lectures from the week, each session started by reviewing the most difficult questions from the quiz questions that were embedded into the video lectures. At the beginning of the flipped classroom session, the module directors presented the five worst performing questions (lowest percent correct), which the module

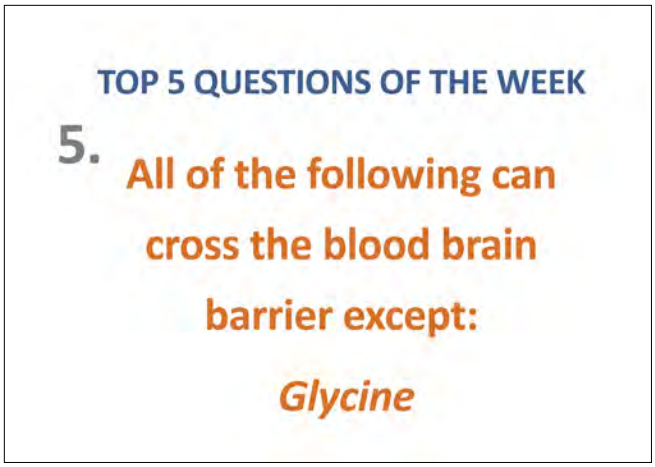

FIGURE 2. Sample question review from the week. Note that the lecture the question came from and the number of students who answered the question correctly is shared in the bottom right corner.

directors dubbed the "top five questions of the week" (see Figure 2). For this segment, the questions were presented one at a time, revealing the percentage of students who had answered correctly. After reminding the students which video lecture contained the question and what the correct answer was, the faculty who gave the lecture was provided with time to briefly re-explain the key concepts to help clear up any confusion on the part of the students. In some instances, less than 20% of the class had answered the question correctly. Showing this to the students helped to reassure them that they were not alone in their struggle to understand complete neuroscience concepts. In other cases, up to 80% of the class had answered the question correctly - but this was still one of the "worst performing questions." Seeing such a high level of performance on a top five question helped to raise student confidence and morale.

Use Case-Based Learning

A list of topics for Flipped Friday session was created based on the objectives from each of the lectures for a given week. Whenever possible, the overlap between lectures from multiple departments was emphasized. For example, if the departments of biochemistry, neuroscience, neurology, and psychiatry all discussed acetylcholine synthesis's role in delirium, the topic of delirium was prioritized. Building off these topics, a series of 3-4 vignette-style cases integrating these questions was then developed. Each case began with a brief patient history including a subjective complaint and objective physical exam findings (see Figure 3). The first questions associated with the case could frequently be primarily based on the anatomy of the disorder. The next question, which was presented with additional case material, would then focus on the pathology. This would then be followed by a question about the diagnosis and then treatment. In this way, the questions of the case unfolded in a way that clinical

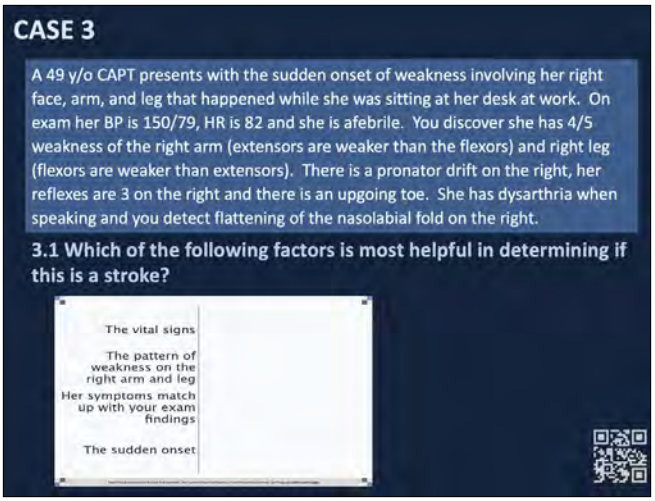

FIGURE 3. Screenshot of case-based learning. Note that the stem is separated from the question. As the case progressed, the stem would update, and a new question would be asked. The QR code took students to PollEverywhere.

cases often present - with history preceding a physical exam, followed by diagnosis, and then ultimately treatment.

Include Military Relevant Content

Once the clinical cases were drafted, military-relevant material was added. This included simple psychosocial additions to each of the vignettes like rank, job title, veteran status, or dependent status. For example: "A 35 y/o SGT working in EOD presents to your clinic…" was the opening line for one of the vignettes. This provided an opportunity to explore what SGT (sergeant, an enlisted rank) and EOD (Explosive Ordnance Disposal, a job) meant. It also provided a chance to explore the potential meaning of multiple demographics (e.g., Why would a 35 y/o be of such low rank?). When the week's lectures focused on military content themselves, questions specific to military content were included in the Flipped Fridays. For example, deployment considerations or population health concerns were included as specific vignette-style questions.

Build a Basic Outline and Invite All Faculty to Critique

A solution to the challenge of determining who would create the cases and how to integrate the content was to have one person create the cases with additional faculty review. This single person crafted a series of three to four cases that integrated the week's content. Once the cases were created, all of the faculty who taught that week's lectures had the opportunity to review the cases and questions for accuracy and relevance to their own material. Providing feedback and making adjustments was promoted. This process worked more efficiently than having each faculty member create a case relevant to their subject area and attempting to coordinate all these individual cases. It also ensured that experts

in the wide variety of subject matter areas covered in each question could review the material for accuracy.

Explicitly Review Strategies for Answering Vignette Style Questions

A clinical vignette-style multiple choice question (CV-MCQ) features a description of a clinical case, including the patient history, physical exam findings, and often the results of clinical laboratory testing, diagnostic imaging, or pathological tissue analysis. The question is typically posed in the last sentence of the vignette, and students must use the information in the vignette to determine the best answer from the list of choices. The CV-MCQ is by far the primary format for testing clinical reasoning skills on medical licensing exams and other standardized tests, and as such, many medical schools now use CV-MCQs for summative assessments throughout the curriculum. Since CV-MCQs are by nature quite lengthy and require the examinee to synthesize multiple bits of information in order to find the answer, students often find them more difficult than questions that test recall of isolated facts, as are common in undergraduate college courses. The module directors, therefore, decided that using CV-MCQs in this flipped classroom approach would provide the most appropriate formative learning experience, allowing students not only to self-assess their level of knowledge but to gain practice in applying that knowledge to clinical scenarios as they would be expected to do on the module's summative assessments and eventually on standardized licensing exams.

To help students gain confidence and become more adept at answering CV-MCQs, the module directors used the first Flipped Friday to explicitly present approaches to solving these types of questions. This included emphasizing the importance of looking at the question at the end of the vignette and reviewing the options before reading the vignette - as it focused on the goal of the student in reviewing the vignette. This approach was further reinforced in the design of the presentation slides by visually separating the question from the vignette (see Figure 2).

Use Think-Pair-Share

In order to engage all of the students, have them take ownership of their own learning, help them engage with each other, and to develop a community of learners, the module directors employed a think-pair-share strategy (see Figure 4; Sampsel, 2013; Tedesco, 1999; Bongers & Heidemann, 2020). The typical think-pair-share strategy is to have the students think quietly about a question before pairing with a partner to discuss their thinking and then having pairs share their answers with the class. In an online space, where students pair using one-on-one chats, the module directors thought it would be better to leverage technical tools (see the section below) and have the students select their answers earlier in the process. Specifically, after students read a clinical

FIGURE 4. Think-pair-share guidance. Note that the guidance directs students to answer the question prior to pairing and that sharing is done using PollEverywhere (see Figure 5).

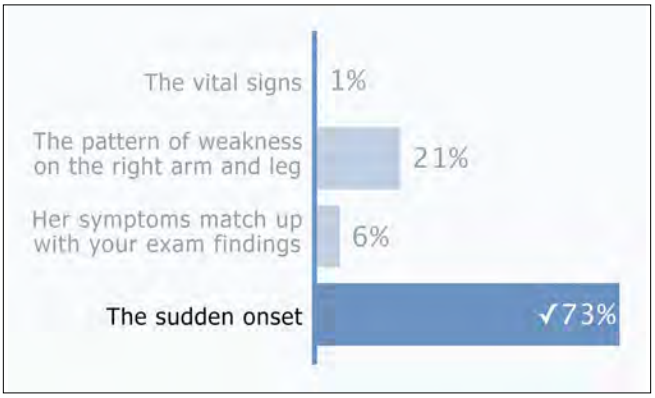

FIGURE 5. PollEverywhere results shared with class.

vignette and question, they were given several minutes to think and review their notes and any materials from the week. Students anonymously selected their answers using PollEverywhere software. Students were then invited to discuss their answers with a partner (pair) for several minutes. Finally, the results of the PollEverywhere were revealed to the class (share). Using a bar graph, the slide would first only indicate how many students selected each option - providing yet another opportunity for students to see how their peers were thinking. Then, the correct answer would be highlighted, segueing to a brief faculty discussion (see section below).

Leverage Digital Tools

In an in-person class of approximately 170 students, it can be difficult to maintain engagement with each learner (Rissanen, 2018). Learners can easily hide behind more vocal peers, and it can also be threatening for learners to participate in such a large group. At the same time, there is no time to allow each learner to engage all the faculty. Teaching in

an online space can make this even more difficult. The use of several digital tools enabled us to navigate these problems (Caspi et al., 2006). As mentioned previously, the use of PollEverywhere software provided a mechanism for students to commit to an answer without letting the entire class know of their decision (see Figure 5). For the pairing aspect of the event, students could engage online via Zoom's © one-on-one chat feature. Similarly, the Zoom © chat feature enabled faculty to have multiple public and private discussions with students about their material - often occurring in parallel to other faculty engaging in similar conversations and with the continuation of Flipped Friday.

FIGURE 6. Faculty had 3 minutes to defend the answer. (kennykiernan, n.d.)

Invite All Faculty to Participate in Defending Answers

The module directors used Flipped Fridays to not only review the week's content but to promote faculty and student engagement with each other. Each faculty member who gave a lecture that week was invited to the session. This typically involved 5-14 faculty. After the correct answer to a question had been revealed, all faculty who taught the material tested in the question were invited to explain the correct answer. This often meant that faculty from multiple departments shared the screen at the same time - truly inculcating for the students that the material was integrated. The faculty were only allowed to use slides that they had previously presented from that week; no new slides or new content were added. The module directors added the last stipulation to ensure

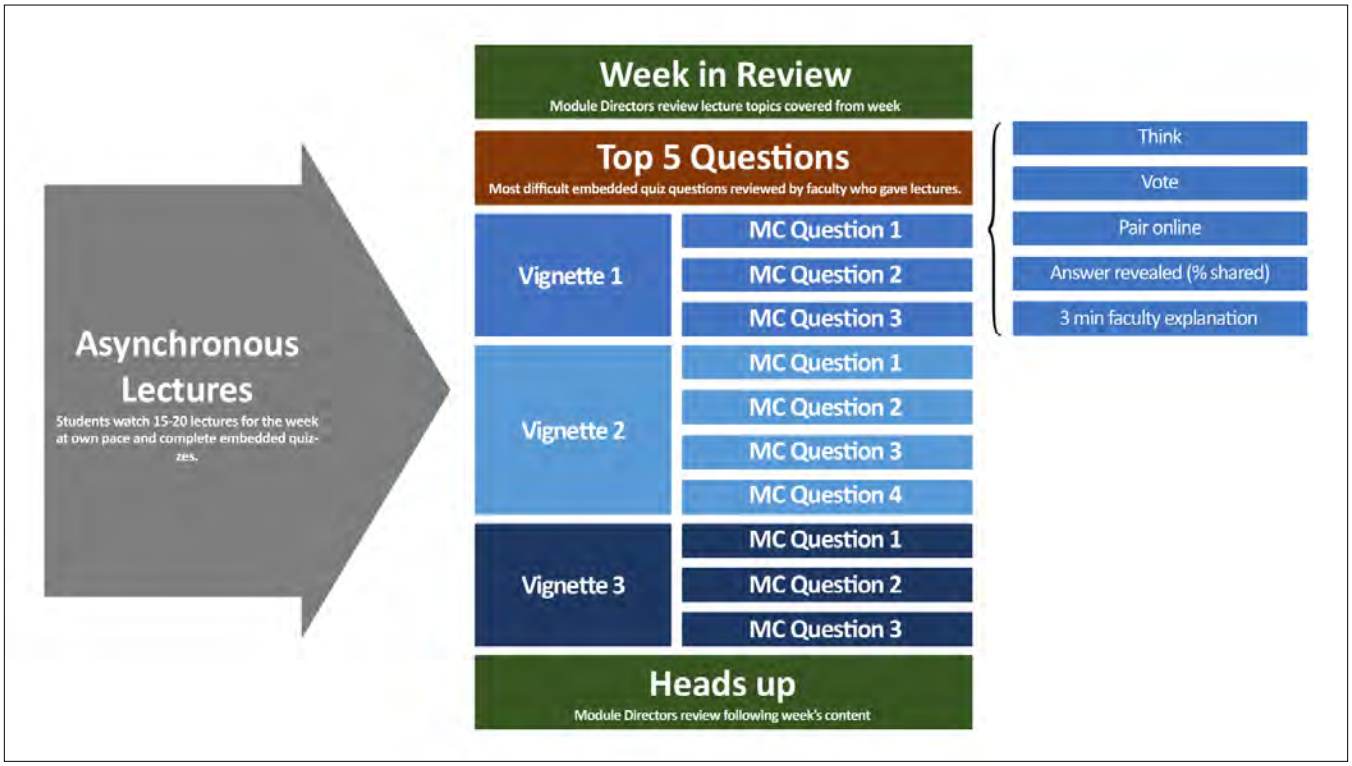

FIGURE 7. Overview of Flipped Friday. Students would watch lectures for the week on their own (gray arrow) and then log in each Friday for the flipped session. The session would begin with a 1-2 min review of the week's topics, using the calendar from that week. This would orient and sensitize students to the content. Questions would then be reviewed based on student performance, with faculty who gave the corresponding lectures using slides from their actual lecture to re-explain the material. Then a series of 1-5 clinical vignettes would be covered, each with 3-8 questions. For each question, students would use the think-pair-share model, where pairing was done via 1:1 online discussions between peers and sharing was done using an online voting system. The answer would be revealed along with class performance. Corresponding faculty would then have 3 min to defend the answer, again using a slide from the actual presentation students watched that week. Students were invited to ask a few questions publicly (1-2 minutes) and, if needed, were then able to engage with the faculty one-on-one online while the next question was shared. When the vignettes were over, a calendar for the following week was shared and students were provided with an overview of upcoming content.

that Flipped Fridays focused on applying previously taught content - not on introducing new content. To ensure that the faculty emphasized only the key concepts, the faculty were limited to 3 minutes total to defend the answer (see Figure 6). This also ensured that all the questions for a Flipped Friday were covered. To further increase engagement, students were encouraged to ask questions of the faculty.

Make it Mandatory

In order to ensure that this activity was having the biggest possible impact on all the students, the module directors elected to make Flipped Fridays mandatory. Although these sessions were recorded for later review, allowing students to only "watch" the session afterward would have robbed them of the interactive experience. This decision was also informed by the desire to instill a sense of belonging to a larger community, especially in the context of being potentially isolated watching the lectures online. Learners who perceive themselves as belonging to a learning community, whether it be in person or online, appear to be more enthusiastic about learning (Vygotsky, 1978). Mandatory attendance was also beneficial for the faculty, as it gave us a more accurate assessment of how the entire class was performing with respect to knowledge acquisition. To ensure that these weekly mandatory sessions did not become too onerous, or compromise LCME (LCME, 2021) requirements, the sessions were limited to 90 minutes each. An overview of the entire process can be seen in Figure 7.

RESULTS

Increased Interaction with Faculty

Each Flipped Friday session was conducted via Zoom with a single link shared with all students and faculty. The link remained the same throughout the module. During the session, students were encouraged to post comments and questions in the chat box for the group. They were also encouraged to connect one-on-one with faculty in the chat box with specific questions about the case or to do a deeper dive into the content based on interest and curiosity. Using the chat feature enabled faculty to engage with multiple students and respond to questions as they would have in a face-to-face environment. Students may also have felt more comfortable asking questions during one-on-one chats, therefore, faculty were likely responding to more questions and promoting greater understanding than they would have in a traditional learning environment.

The one-on-one chats were a tremendous success in increasing individual student engagement, as multiple students could engage each faculty member as they needed to asynchronously. Faculty reported working with dozens of students at the same time. This is a feat that would be impossible in a purely "live setting." One drawback to having this completely online did not know how many students were engaging faculty in one-on-one discussions. One benefit to consider for the future is having all 170 students physically in the lecture hall while still using the online chat function to better establish a pace to the instruction.

Improved Ability to Engage Students

Students routinely reported that Flipped Fridays helped them connect what they were learning to clinical medicine. Pre-clerkship students can quickly become burned out as they absorb tomes of new material without a clear patient connection (Mazurkiewicz, 2012). The clinical cases helped the students recognize how the basic sciences contributed to clinical care and motivated them to be more engaged in all other aspects of the module. Faculty routinely comment that students in the neuroscience & behavior module ask more questions, do more additional reading, and come more prepared for small group activities.

Improved Learning Climate

Both formal and informal feedback from students indicated that Flipped Friday played a key role in creating a positive learning environment for the neuroscience & behavior module. The formative nature of the exercise created a safe space for students to discuss their ideas with their peers, make mistakes and ask questions. When students were able to answer a question correctly, their confidence was raised by demonstrating their mastery of the material to their classmates. When they did not know the answers, they were able to see that many other students were also struggling with the same concepts, reassuring them that they were not underperforming compared to the group. This reassurance was aided by the humility of many faculty members, who were willing to admit that they did not always know the answers to questions from other disciplines. Additionally, the act of bringing the entire class together with multiple faculty members from different departments helped to foster a sense of connectedness among all parties. Students mentioned being impressed that so many of their teachers were willing to invest the time to come to the sessions and work collaboratively to help the students reinforce, integrate, and apply their new knowledge. This helped the students to develop a stronger sense of trust and partnership with the faculty of the neuroscience & behavior module, making them more willing to engage in the designed curriculum rather than relying on outside resources to support their learning.

Improved Community of Learners

The hope was that the use of our Flipped Friday would promote a community of learning involving both students and faculty. Pre-COVID, during these large group review sessions, students would sit together with friends to discuss cases, creating their own learning community. After Flipped Friday transitioned to an online format, students continued

to create small learning communities in the virtual environment. Students met together in a variety of ways to share thoughts on the cases. Some met in small classrooms during the session where they could discuss in-person while practicing social distancing, others communicated together using the chat box, while other communities were able to discuss using separate virtual meetings and re-joining the larger group after the "share" portion of the exercise was completed. Using these multiple methods of being together allowed students to retain that sense of belonging which enhances learning and social connectedness.

DISCUSSION

Unexpected Benefits

In addition to achieving the benefits described above, implementing Flipped Fridays had several other unexpected benefits. First, it provided a mechanism to integrate the material for the faculty. Faculty got to see what was being covered in other lectures and hear how their colleagues approached content. This resulted in numerous faculty conversations about changing their lectures for future years to align the content. This multidisciplinary level of integration (Harden, 2000) was something that had not been achieved previously. It was only when the faculty were in an organic situation that required them to see each other's work. Similarly, it also helped faculty see different approaches to teaching. Faculty members who were accustomed to text-heavy slides with limited visual engagement got to see examples of how a dynamic, animated visual slide could be much more engaging for students (Mayer, 2009) and updated their slides for the following year.

The Flipped Fridays also helped the faculty appreciate where the students were developmental. Faculty shared anecdotes like not knowing that the students covered "so much biochemistry" or that they had no idea they "didn't see clinical cases until after the module." In many cases, this helped faculty hone their own curriculum to a more appropriate level, focusing on what the students needed to learn for this phase of their training (Vygotsky, 1978).

Lastly, with the COVID pandemic struck and all instruction, not just lectures, had to move to an online space, Flipped Fridays provided us with a tried and tested method for engaging students in the application of their knowledge that could easily be moved online. This weekly mandatory check-in became the one time that all the students were "together" and provided a much-needed space for the faculty to encourage and support the student's efforts (see Figure 8) while also allowing the students to engage with their faculty. Although this transition challenged our ability to establish our desired learning climate, it also provided an opportunity to further explore and improve how to engage

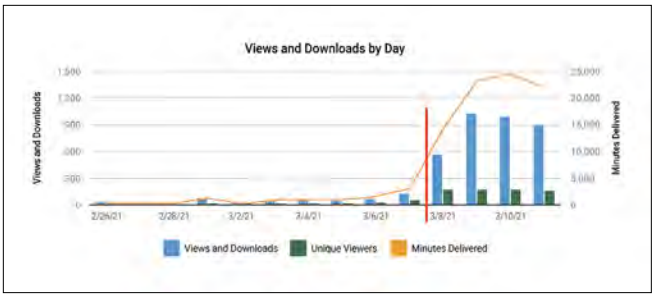

FIGURE 8. Graph of student engagement with online lectures. The red vertical line indicates the start of the module, with a notable increase in views and content delivery starting afterward (to the right). This graph along with reassurance from the faculty communicated to the students that they were doing an excellent job engaging with the content.

students in a purely online space. These are lessons learned that USU's neuroscience & behavior module will continue to employ after the COVID pandemic has resolved.

FUTURE WORK

The USU of Medicine is currently exploring implementing Flipped Fridays into all the pre-clerkship modules. Additionally, models for including even more faculty into each week's review session are being explored. For example, in weeks that a certain department did not have any lectures they were often not invited to the Flipped Friday. However, this prevented them from being able to answer questions related to their field and reduced their visibility of the entire curriculum.

ETHICS DECLARATION

The opinions, conclusions, and recommendations expressed or implied do not necessarily reflect the views of the Department of Defense or any other department or agency of the federal government.

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