INNOVATIONS in pharmacy

Volume 7 | Number 4 Article 12

11-14-2016

Combining Chalk Talk with PowerPoint to Increase In-class Student Engagement

Swati Betharia

Manchester University College of Pharmacy, Natural and Health Sciences, swati.betharia@mcphs.edu

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Cover Page Footnote
The author wishes to thank Dr. Mary E. Kiersma and Dr. Lorin M. Sheppard for help with designing the session, and Dr. Robert D. Beckett and Dr. David F. Kisor for reviewing this manuscript.

Combining Chalk Talk with PowerPoint to Increase In-class Student Engagement

Swati Betharia, PhD
School of Pharmacy, MCPHS University

Abstract

In striving to attain a higher degree of in-class student engagement, and target a larger number of preferred student-learning styles, this case study describes a multimodal teaching approach. PowerPoint slides have gradually gained popularity over the more traditional chalk and talk lecture design. The student population in today's age seeks more non-passive modes of information delivery. Numerous novel approaches to enhance active learning, such as flipped classroom and problem-based learning, have recently been explored. While working well for therapeutic and lab-based courses, these formats may not be best-suited for all basic science topics. The importance of basic science in a pharmacy curriculum is well emphasized in the 2016 ACPE Standards. To actively involve students in a pharmacology lecture on diuretics, a session was designed to combine the PowerPoint and chalk talk approaches. Students created 10 concept diagrams following an instructor, who explained each step in the process using a document camera. For visual learners, these diagrams provided a layered representation of the information, gradually increasing in complexity. For learners with a preference for the reading learning style, the information was also available in corresponding PowerPoint slides. Scores from pre- and post-session quizzes indicated a high level of concept understanding and recall (median 1 [IQR 0 – 2] vs 4 [IQR 3 – 5]; p<0.001). The student perception survey data reported higher in-class attention levels (76%), an appreciation for the utility of self-created concept diagrams (88%), and a call for additional sessions being presented in this format (73%). Targeting a variety of student learning styles by using the active development of concept diagrams, in addition to traditional PowerPoint slides, can promote student engagement and enhance content understanding.

Key Words: Concept diagrams; chalk talk; student engagement; PowerPoint; VARK learning-styles

Introduction

The newly established 2016 Accreditation Council of Pharmacy Education (ACPE) Standards emphasize the development of a pharmacy curriculum that prepares graduates with knowledge in foundational sciences with the ability to apply this knowledge to the practice of pharmacy and the advancement of the profession.[1] This is in line with the 2013 Center for the Advancement of Pharmacy Education (CAPE) Educational Outcomes, which include the development of a 'Learner' (subdomain 1.1.), as a student who should be capable of integrating and applying the knowledge from foundational sciences, including pharmaceutical, social, and clinical sciences, to solve therapeutic problems and advance population health.[2] Based on these recommendations, many new and established pharmacy programs are moving towards implementing an integrated curriculum, where the importance of science and its applicability to the practice of pharmacy are appropriately emphasized.

The attention level of students tends to fluctuate during standard lecture hours.[3, 4] Various active learning techniques, such as patient cases, problem-based learning, and flipped classroom have been utilized to enhance student engagement and learning.[5, 6] Basic science topics are often complex, and require content to be broken down and taught by an instructor, before it can be used by students to solve complex therapeutic problems. Therefore, prior to employing active learning techniques, which often need significant class time, science faculty are required to make judicious use of teaching tools to present their content in an understandable and engaging manner. These choices may be influenced by the differences in student learning preferences, which can be classified into visual, aural, reading/writing or kinesthetic (VARK), based on a survey developed by New Zealand educator Neil Fleming in 1987.[7] While the survey does not suggest hard and fast boundaries, it classifies visual learners to prefer diagrams, graphs and charts; aural learners to prefer lectures recordings, discussions, and seminars; reader/writer learners to prefer books, handouts, slides and notes; and kinesthetic learners to prefer real-life examples, models, demonstrations and physical activity.[8]

Various studies have reported a wide range of learning styles within different cohorts of medical, dental, nursing and pharmacy students[9-12] and have found a significant number of students preferring a multimodal form of learning, which combines two or more learning preferences. These studies have implicated that redesigning traditional lectures to include additional teaching tools, which can target a larger variety of learning styles, can strengthen learning for students. The session described in this case study was designed to include the creation of concept diagrams, in addition to PowerPoint (Microsoft Corporation, Redmond, WA) lecture slides, to

Corresponding Author: Swati Betharia, PhD
179 Longwood Avenue, Boston, MA 02115
T: 617-879-5943; E: swati.betharia@mcphs.edu

target multiple learning preferences. With an increased level of expected student participation built into the session, this mix of teaching tools offered a much needed variety in the content delivery method for a complex, somewhat tedious science topic.

Case Description

Curricular setup

Manchester University College of Pharmacy was established in 2011, and the curriculum for its four-year Doctor of Pharmacy (PharmD) program was designed in an integrated format. The first professional (P1) year of the curriculum incorporated courses on Biomedical Sciences, which included lectures on anatomy, physiology and relevant pathophysiology of the cardiovascular and renal systems taught in part by the author. The P2 and P3 years of the curriculum included a series of integrated pharmacotherapy (IPT) courses, with a duration of 4 to 5 weeks each. The general design for these courses involved sequential sessions with a brief review of physiology and pathophysiology, followed by pharmacology, medicinal chemistry and therapeutics related to the disease state being taught by a team of two to three faculty members. Each IPT module met for 10 to 11 hours a week, with individual lecture sessions being 2 to 3 hours long in duration.

Topic selection

The cardiovascular system is a complex system with numerous interconnected parameters, some of which are also related to the renal system. Both these body systems involve an in-depth understanding of concepts that gradually build upon each other. The Cardiovascular I IPT module (P2 Fall) included a three-hour session on the pharmacology of diuretics. This drug class essentially consists of six subclasses, each affecting different transporter systems in distinct nephron regions. The mechanisms of action for each subclass can directly be related to respective clinical uses, adverse effects and contraindications. A three-hour session on diuretics delivered by simply talking through this information using standard PowerPoint slides or handouts was anticipated to be a struggle for students, both in terms of concept understanding and maintenance of attention levels. This session was expected to lay the foundation for the therapeutics lectures on hypertension and heart failure that followed. Diuretics, as a drug class, were also a part of the Renal System IPT offered in the P3 year, making a thorough understanding and long-term retention of these concepts a desired goal while designing this session.

Session design

Prior to the first-time delivery of this lecture, the author held discussions with the Director of Instructional Design and the Director of Assessment at the College, where different ideas to present this information were discussed. A variety of diagrams depicting different sections of a nephron, distinct ion transporters and their involvement in the mechanisms of action for different diuretic subclasses were available through standard reference textbooks[13, 14] and other online resources. However, these pictorial representations were often complex in nature and in certain cases contained different pieces of relevant information. An in-class session where the instructor would compile information from different sources and sequentially draw out relevant concepts using a document camera seemed promising. To provide further structure to this activity, the session was modified to include instructor-created drawing workbooks for each student, which could be filled out alongside the instructor. To create a workbook, the instructor drew out diagram skeletons covering all major concepts related to the topic (Table 1) on 10 sheets of paper. This workbook was scanned and posted on the online learning management system. Prior to the session, an announcement was made instructing each student to leave university-issued laptops behind, and instead bring individual printed copies of the workbook and colored pens to the session. A PowerPoint presentation was used to deliver the session in conjunction with the workbook, but was only posted after the session was completed. This was clearly communicated to the students ahead of the session, to alleviate any anxiety related to not having access to the slides prior to the midterm exam.

The workbooks were also designed to include blank tables for drug names, mechanisms of action, clinical uses and adverse effects for each diuretic subclass containing corresponding concept diagram skeletons (Figure 1). With the completion of this workbook, students were able to compile information from a 35-slide PowerPoint presentation into a 10-page workbook, and could use the latter as a complete source of information to guide their preparation for a subsequent midterm exam. The session was recorded using Tegrity Lecture Capture (McGraw-Hill Higher Education, Burr Ridge, IL), and the workbook completed by the instructor in class was posted after the completion of this three-hour session. In preparation for the midterm exam, students were also encouraged to practice filling out blank copies of the same drawing workbook, which were available via the online learning management system.

Activity specifics

The following paragraph further describes the in-class use of this approach using thiazide diuretics as an example. Beginning with a skeleton diagram for the site of action for these drugs (Figure 1), the instructor drew out various transporters present in this region and explained relevant ionic movements in a step-wise manner. Once the normal physiology was established, the mechanism of action of thiazide diuretics was added to the figure, depicting how the blockage of a specific transporter would result in a diuretic effect, as well as corresponding adverse effects in the body. The most common examples of the drug class were added to the page, and the

table was then completed, correlating mechanisms of action, clinical uses and adverse effects where possible (Figure 2). Upon completion of this page in the workbook, five corresponding PowerPoint slides related to these drugs were projected and discussed in an attempt to underline the overlap of information between the two sources. These slides were shared with the IPT faculty team and the subsequent medicinal chemistry and therapeutics sessions on diuretics included the same slides to reinforce student retention of concepts.

Assessment of outcomes and student perceptions

The following year, the session was formally assessed using pre- and post-session quizzes, and the Manchester University institutional review board (IRB) approved this study as exempt from review. The potential use of information collected using the pre- and post- session quizzes was explained to the students and two exam points were offered as an incentive for the completing the same quizzes. At the beginning of the session, five minutes were allotted to students to attempt a knowledge-based pre-session quiz. At the end of the session, the students were given 10 minutes to complete a post-session quiz without the help of their completed workbooks. This post-session quiz comprised of the same five knowledge-based questions as the pre-session quiz, and also included a nine-item survey asking students to rate their perceptions on different facets of the session using a 5-point, strongly disagree to strongly agree Likert scale. The tenth question was open-ended, asking for suggestions to improve the session in the future. A maximum score of five points could be attained in each quiz. Both quizzes were graded by a staff member blinded to the study, and scores obtained had no effect on the students' course grades submitted to the registrar.

One week after this session, a midterm exam including six questions (worth 12%) based on the pharmacology of diuretics was administered. Each lecture objective (Table 2) was tested at least once in each of the three assessments. The assessment questions on the two quizzes and the midterm exam ranged from multiple choice, multi-select to fill-in the blank and short answer questions. Higher up on the Bloom's taxonomy, these questions were designed to test the concept understanding and application, and less recall. No figures in the workbook were asked to be redrawn as an assessment, to discourage simple cramming of information on diagrams without conceptual understanding.

The performance on the pre-session quiz was compared to that on the post-session quiz and the midterm exam using inferential statistics. In a class of 76 students, 74 completed the pre-session quiz (response rate of 97.4%), and 71 completed the post-session quiz (response rate of 93.4%). The average score (± SD) for the 71 students who took both the pre- and post-session quizzes (5 points each) increased from 1.10 ± 0.96 to 3.94 ± 1.26. This data analyzed using the Wilcoxon Signed-Rank two-sample test depicted a significant improvement in performance (median 1 [IQR 0 – 2] vs 4 [IQR 3 – 5]; $p<0.001$). SPSS Statistics version 22 (International Business Machines Corporation, Armonk, NY) was used to calculate inferential statistics. The 71 students earned an average of 77.14 ± 17.14 percent on the six questions based on diuretic pharmacology in the midterm exam, which was comparable to their overall averages on the exam as a whole (76.95 ± 10.39 percent). A Pearson's test indicated no significant correlation between individual student performance on the pre- or post-session quizzes and the performance on corresponding midterm exam questions (correlation coefficients of -.072 and .121 respectively). There was however, significant correlation observed between pre- and post- session quiz performances (Pearson's correlation coefficient of .252; $p<0.05$), implying that students who performed well on the pre-session quiz also performed well on the post-session quiz, and *vice versa*. Responses to the 10-item post session survey are available in Table 3, with data collapsed for strongly agree (SA) and agree (A); and strongly disagree (SD) and disagree (D) responses.

As this activity required multi-tasking and frequently switching focus between two different sources of information (drawing workbook and PowerPoint slides), the instructor was concerned about losing students midway through the session. However, student performance on the knowledge-based questions on the post-session quiz implied this not to be a significant problem. The data also suggested that managing multiple tasks simultaneously, such as following the PowerPoint presentation, listening to the instructor, and drawing concepts alongside the instructor, was not perceived as problematic or stressful by a majority of students (N=39, 55% SA/A). In fact, a common theme that emerged from the final open-ended question on the 10-item survey asking students for suggestions to improve the session was that the PowerPoint slides be uploaded on the online learning management system prior to the session (N=13, 18.3%), which shows a willingness to perform additional tasks and manage more resources during this already task-heavy session. In a somewhat split response, 37 students (52%) agreed/strongly agreed to anticipated outside-class study time for this material being lower compared to other traditional lectures. However, the study did not involve asking students to track the number of hours spent studying. Fifty-four students (76%) agreed/strongly agreed that their level of in-class attentiveness was higher, and this was also observed anecdotally by the instructor. Overall, 52 (73%) students were in favor (SA/A) of additional lectures being presented in this format.

Though not formally recorded, the instructor had numerous conversations with students during the same and even consequent semesters, where the general sentiment "I can still

see all the diagrams when I close my eyes" was often expressed. Semester-end instructor and course evaluations were completed anonymously by 74 students (response rate of 97.4%). In response to the open-ended question asking 'What aspects of the teaching or content of this course were especially effective?', 49 students (66.2%) referred specifically to this session. Some sample comments are as below.

> "The drawings of the nephron and diuretics were especially effective. I like how the information was broken down into steps making it simple to understand."
>
> "Drawing things out helps information stick! I don't have to memorize anything because these drawings make me remember things from semesters ago!"
>
> "The method used to explain the nephron loop and the action that each type of diuretic had at each particular location was really helpful in learning what could have been very complicated material. The handouts in which we added things to as we followed along was extremely helpful in the learning process."
>
> "I like how we worked through many of the diuretics concepts during class. I felt that when I left the classroom, I was knowledgeable on the subject. I felt that I had learned most of the information during class and I spent less time outside of the classroom working on the information."

Identification of Case Themes

Creating student engagement

Compared to students from a few decades ago, the Millennials are more comfortable with technology, and show a strong compulsion for multi-tasking, which can sometimes be construed as a lowered attention span.[15] The traditional concept of "sage on the stage" often proves ineffectual for this generation of students,[16] who tend to prefer more interactive environments and a variety of learning resources to create meaningful personalized experiences worth their time spent in the classroom.[17] Current educators are obligated to make judicious decisions regarding their lecture designs, which probably best lie somewhere in between contrasting approaches ("sage on the stage" versus flipped learning). Utilizing a larger variety of teaching techniques to impart the same information in an interactive, non-passive manner, while integrating available technology where well-suited, is imperative to allow the learners of today to achieve their full potential.

Numerous studies have explored the importance of note-taking in the classroom. Khan *et al* reported that taking notes helped students in the learning process, which led to better performance on assessments.[18] Additionally, students provided with cognitive scaffolding in the form of skeleton (incomplete) lecture notes to be filled-in during the lecture, have been reported to perform better that students taking their own notes without a standard template.[19] Others have shown that students taking notes by hand (often in their own words) remembered conceptual material better and outperformed students taking notes on their computers (often verbatim from the instructor).[20,21] Given the lure of computer-aided distractions (Facebook updates, text messages), Fink reported that banning digital note-taking in the classroom led to increased attentiveness and improved performance.[22]

The current approach was designed to provide students with a structured, scaffolded activity. To include variety in the teaching modality, PowerPoint slides were used in conjunction with a drawing workbook to deliver the same content in two ways. Based on the ongoing debate on the benefits and harms of student access to portable electronic devices in the classroom,[23] and also to eliminate an additional task for students to focus on, students were asked to leave their university-issued laptops behind for this session. This resulted in some initial degree of resistance and apprehension amongst students (reported anecdotally). However, as the session progressed, students seemed to be pleasantly surprised by how this step-wise activity made the content appear both enjoyable and easier to grasp. Students were able to fill-in these concept diagrams in varying personal styles (e.g. using color schemes of their choice), while a basic degree of uniformity was still maintained based on the provided template. With the completion of this workbook, students essentially had created their own set of study notes, which they could use as a resource for future reference. Prior to the session, the instructor made no specific announcements regarding the posting of her own completed workbook on the online learning management system. This ensured that the students were relying on their own note-taking abilities to obtain this information during class. As this entire activity was built into class time, it did not require students to complete any pre- or post-class assignments outside of class. This aspect can be altered based on the personal preference of the instructor(s). Notably, while planning a session like this, the class size is not likely to be a significant restricting factor. The activity can even be easily extended to distance or online learners, as long as the audio-video technologies available are reliable.

Activities designed for note-taking come with the obvious consideration that this may be cognitively demanding for some students. Listening to the instructor while paraphrasing the content into complete and accurate notes is a skill which comes with practice. For students who write more slowly, this task may be difficult, and could be compounded by the fact that the instructor may be speaking at a fast pace or inaudibly.[24] Additionally, it is important to carefully consider the utility of such a session, and assess if the purpose is to

simply allow students enough time to complete the skeleton lecture notes, or to incorporate significant in-class learning and retention of material as well. Ensuring adequate time to run these sessions will allow for both, and therefore result in higher student satisfaction. One advantage of this multimodal teaching technique is a relatively slow pace of delivery of complex information, which requires the instructor to progressively draw out and explain each concept in detail. As all pertinent information related to each diuretic subclass was compiled on a separate page, the instructor was able to point out connections, overlaps and differences between different subclasses by sifting between pages of the workbook. Using lecture capture technology for both video and audio recording is bound to be advantageous for such a session, providing students the option to revisit earlier stages of a gradually constructed complex diagram.

In preparation for the midterm exam, blank workbooks were available to students via the online learning management system to be used to practice information recall. However, the number of times students made use of this option was not formally tracked. To ensure that students had access to a complete notebook, the instructor's copy was scanned and uploaded online after the session as well. The intent for this decision was to provide a secondary "safety net" for students to complete or cross-check their notes for accuracy. It was however observed that some students used the instructor copy to completely replace their own notes. In additional sessions run in this format since, some students were observed to only be listening to the instructor but not taking any notes, relying on the completed instructor's copy posted after the session to study. Based on a personal teaching philosophy, this process can be altered to leave the completed workbook unposted. Allowing computers (and the distractions that come with) to a session where the instructor's copy of the completed workbook is to be posted after the session may result in significantly less student engagement and an overall decreased effectiveness of the activity. It is imperative to stress the importance of each student participating in the activity, emphasizing how note-taking by hand can lead to better concept understanding and retention.

Multimodal teaching to address multiple learning styles

Chalkboards, overhead transparencies, and document cameras have been used to explain concepts in the classroom for many years. The traditional "Chalk Talk" methods may promote a more spontaneous student-teacher interaction, which nudges students to be active participants and not passive observers. Allowing for more natural pauses and flexibility, the chalkboard can be considered to be more student-centered.

However, with advances in technology, a vast majority of faculty have transitioned to using PowerPoint slides to deliver their lectures. Ease of content delivery and the reassurance of having access to lecture content in its entirety render this tool appealing to both faculty and students respectively. While student performance on exams may not improve with its use, the general theme remains that students perceive lectures taught using PowerPoint to be better organized and easier to understand.[25] Compared to traditional lectures, they are also considered to be more interesting[26] and easier to take notes with.[27,28] In today's age where students are accustomed to constant visual stimulation, the use of technology and computer programs is encouraged in many schools as a strategy to hold student attention.

Taking advantages of the two approaches into account, the case described herein was designed to use both in conjunction, and was hypothesized to achieve a more productive and engaging learning atmosphere. The literature on learning styles provides further support for this combined approach. The most widely used assessment to track this variation is the VARK scale developed by Neil Fleming.[7] Students have been found to vary in their preferences from unimodal to multimodal forms of learning, (i.e. a combination of visual, aural, reading/writing, or kinesthetic forms of learning). Published results on learning style preferences in pharmacy students cover different indices, such as the Kolb Learning Style Inventory and the Index of Learning Styles,[29] the Honey and Mumford's Learning Style Questionnaire,[30] and the Zubin's Pharmacists' Inventory of Learning Styles.[31] Elkalmi et al. used a VAK scale on pharmacy students, and reported a high majority of students to prefer the visual form of learning.[12] Skeptics suggest that while students may have a 'preference' for one form of learning, they have the ability to learn from all different mediums of instruction.[32] Regardless of the learning index used or results reported, there is growing agreement that teaching to a single learning style may not be best suited for all students, which has led to a call for diversity in instructional design in the classroom.

From the instructor's perspective, running a session like this involves planning and a thorough understanding of topics being presented. Faculty members who are visual learners themselves may be able to utilize this multimodal approach more effectively. Based on the author's personal experience, practicing creating these diagrams ahead of the session is a useful exercise. Also, not every topic may lend itself to this approach. It is important to ensure that the activity does not become forced and unnecessary, involving simply drawing out what is already available as an image on a PowerPoint slide. The students will only appreciate the session and participate if the diagrams drawn in class tell a bigger story. It is recommended that activities seek to map multiple interrelated concepts as a single image in a layered, stepwise manner. The image should gradually increase in complexity, giving students the opportunity to grasp the basics first and build upon them.

The ideal outcomes should be that the entire lecture can be visualized based on these concept diagrams, and that the students feel confident about their level of understanding simply based on attending the session. A basic level of technology aptitude is required from the faculty member running the session, ensuring that transitions between the document camera and the projector slides is seamless, and that video (magnification, handwriting) and audio (speech quality and pace, recording) quality is maintained for the length of the session.

In addition to targeting multiple learning preferences, PowerPoint slides were also used in conjunction with the workbooks in an attempt to relieve student anxiety. Some level of anxiety and frustration is commonly associated with traditional chalkboard lectures, where students' entire focus is limited to being able to take down comprehensive notes. Providing PowerPoint slides which listed each step used to create the diagrams as sequential bullet points assured students complete access to any missed information. This allowed for students to focus on concept understanding during the session. Switching frequently between workbook pages and corresponding slides allowed the needs of learners with visual, aural, reading/writing and multimodal learning preferences to be met. Kinesthetic learners who may benefit from physical models of ionic transporters and corresponding diuretics, are yet to be fully engaged with the current set-up. This is an important facet to be explored in the future.

Basic science in the pharmacy curriculum

Basic science topics are often dry, and may benefit from utilization of a combination of teaching tools to pique student interest and target a larger number of learning preferences. Additionally, these topics taught with an emphasis on their applicability to pharmacy practice can boost student motivation. Students have traditionally found mnemonics and other memory tricks helpful for long-term retention of knowledge, and the visual form of learning described in this case study can have a similar applicability. During the lecture, the instructor related the science (physiology, pathophysiology, drug mechanism of action) to practice (drug uses, adverse effects, contraindications). In addition, it was further elaborated that instead of relying solely on memory for the long-term retention of drug-related therapeutic facts, a strong understanding of the underlying science could serve as a life-long fallback knowledge base. Practice faculty members teaching corresponding therapeutics lectures noted a higher degree of content recall and basic science application in students solving provided patient cases.

Considerations

This specific cohort of students was not surveyed to determine learning styles, and were simply predicted to have a range based on the class size. Also, students now had two resources to study from instead of one, which in some cases could be conceived as twice the amount of information to be studied, and lead to increased anxiety. As the PowerPoint slides were not available in advance, attending this session was potentially less beneficial for students with a reading/writing learning preference. Future iterations of the session have involved providing these slides to students to print and bring to the session, maintaining the stipulation for students to leave computers behind. Printing may be a monetary or an environmental concern for some students. The availability of electronic note-taking applications using a stylus pen is a viable alternative, but the technique may lose some of its effectiveness.[20,21] This approach could also be challenging for students who are unable to keep up with multiple tasks simultaneously. While some student comments indicated a decrease in class distractions and reduced need of outside class studying time, these parameters were not formally tracked. Anecdotal evidence based on student-instructor conversations indicated a strong and long-term recall of concepts taught using this approach compared to others using traditional lectures, however, conducting a separate quiz on this topic at the end of the semester and/or at the beginning of the P3 fall semester would have provided more reliable data to back this theme.

Impact and future directions

With an ever-evolving target audience, it is imperative for the academy to also keep up with changing learning preferences and desired expectations. The use of new active learning strategies like problem-based learning and the flipped-learning model have added significantly to the literature. Equally important is the utilization of traditional teaching tools in novel ways to enhance learning, and create a personalized learning environment for our students.

Pharmacy education has been producing adept pharmacists for decades, and limited literature is available on the learning style preferences of pharmacy students.[12, 29-32] Thus far, the studies have reported no or only marginal improvements in student performance on assessments, when taught using teaching techniques tailored to individual learning preferences. While this implies that students have the ability to adjust to different teaching styles and perform adequately on standard competencies, there is some weight in considering other facets such as student engagement, motivation, and satisfaction, which are attributes often left unmeasured by standard assessments. It may not be necessary for all faculty to conduct a VARK analysis of enrolled students and tailor teaching styles accordingly. However, the author does emphasize that incorporating a mix of teaching techniques to deliver the same content in a variety of different ways can help better engage student attention and optimize the utility of class time.

Based on the success of the session described herein, additional instructors at Manchester University have also experimented with this technique. The author has since also utilized the technique to teach other topics in pharmacology, such as treatment of congestive heart failure, antiplatelet agents and anticoagulants. In an interesting modification to this approach, the instructor used a longitudinal drawing workbook to build on concepts during three years of the integrated curriculum. In the first year, the workbook was used to fill-in concepts related to anatomy, physiology, and related pathophysiology. In the second year, the same workbook was used to add on pharmacological (and related therapeutic) aspects related to the cardiovascular system. In the third year, the workbook was brought back in, and the rationale for potential uses or contraindications of the same drugs in renal disorders was highlighted. This is in line with the newly enforced ACPE standards,[1] which promote the curriculum to consistently and longitudinally build on itself.

The next obvious steps to extend this study further would be to find ways to involve other faculty in the activity as well. If faculty teaching together in an integrated course can identify ways to incorporate the same workbook into medicinal chemistry and practice lectures, it would result in numerous benefits. First, students would take the exercise even more seriously, and would be able to see direct connections between science and practice emphasized from different faculty perspectives. They would also have a complete resource with important interrelated concepts mapped together to view at a glance. Second, this would encourage faculty to gain a better understanding of each other's specialty areas. This would also reduce the number of possible contradictions in content taught by different faculty team members. Third, practice faculty members could include these workbooks as a reference source when students are on introductory or advanced pharmacy practice experiences, creating another opportunity to reinforce why different components of the didactic curriculum are interrelated and relevant to their future careers. As a whole, this could then be considered as a physical proof of science and practice integration in the true sense, making a case for participating schools to be complying with and in a sense exceeding the newly approved standards for accreditation.[1]

While this case study was able to move one step forward in combining teaching techniques to targeted three of the four learning styles in students, further exploration to better involve the kinesthetic learners is warranted. This may be easier done in a lab setting or in therapeutic lectures (e.g. patient counselling, role playing). However, ideas for creating similar activities for science lectures in a didactic setting are worth exploring.

The application of this multimodal form of teaching extends beyond pharmacy education. Faculty teaching in other healthcare curricula with professional or undergraduate degrees can utilize this technique. As with any form of instructional design, not every discipline or topic within a discipline may be suitable to teach using this method. Complex concepts with layered levels of difficulty, which can be broken down and then gradually built back up, are likely best suited for this method. The willingness, comfort level, and time commitment from faculty to be able to execute this in class are considerations to be kept in mind. Combining the traditional chalkboard method with modern PowerPoint slides can enable faculty to attain a desired balance of student engagement, concept understanding, and knowledge-retention in an anxiety-free environment. With no requirements for elaborate classroom equipment or expensive computer software, the technique is easy to apply and has promising potential for future growth.

Disclosures: The author has no conflict of interest to disclose.

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Table 1. Diuretic pharmacology workbook topics
1. Process of urine formation, countercurrent flow, interstitial fluid concentration gradient
2. Sites of action for six diuretic classes in a nephron
3. Potassium wasting phenomenon
4. Carbonic anhydrase inhibitors
5. Osmotic diuretics
6. Loop diuretics
7. Thiazide diuretics
8. Sodium channel blockers
9. Aldosterone antagonists
10. Antidiuretic hormone (ADH) antagonists

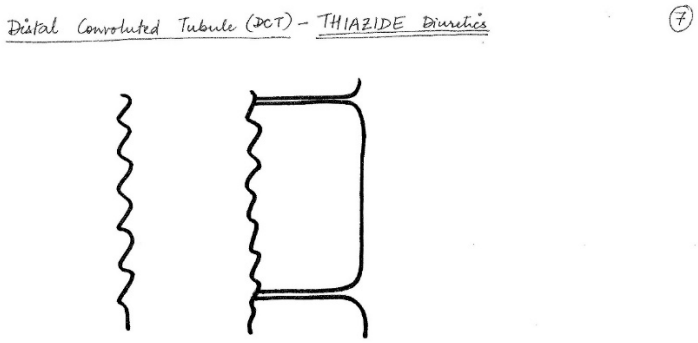
Table 2. Diuretic pharmacology lecture objectives
1. Describe the steps involved in tubular reabsorption with respect to nephron regions involved, corresponding concentration gradients and flow patterns
2. Explain the 'potassium wasting' phenomenon
3. Given a specific nephron region, list the steps, transporters and enzymes involved in ionic movement
4. Given a certain diuretic (drug/class), list the mechanism and site of action, clinical uses and adverse effects

Table 3. Student perceptions of the diuretic pharmacology session (n=71)

	For each of the following, circle the response that best describes your level of agreement[a]	1 or 2 (SD or D) n (%)	3 (N) n (%)	4 or 5 (A or SA) n (%)	Median (IQR[b])
1	I was worried about not being provided with lecture slides until after the lecture was completed.	26 (37)	12 (17)	33 (46)	3 (2 – 4)
2	The instructor drawing/mapping concepts in class helped me better understand the material compared to traditional lectures involving projection of Power Point slides.	3 (4)	10 (14)	58 (82)	5 (4 – 5)
3	Drawing the concepts myself along with the instructor helped me understand the material better, compared to only watching the instructor draw these.	1 (1)	8 (11)	62 (88)	5 (4 – 5)
4	It was difficult to manage multiple tasks simultaneously during the lecture (e.g., looking at the projected Power Point slides, listening to the instructor, drawing concepts based on the instructor's drawings).	39 (55)	21 (29)	11 (16)	2 (2 – 3)
5	I was able to understand the connections between the in-class drawings and the corresponding Power Point slides presented.	2 (3)	12 (17)	57 (80)	4 (4 – 5)
6	My level of attentiveness was higher during this lecture based on the level of active participation required.	0 (0)	17 (24)	54 (76)	4 (4 – 5)
7	It was helpful to reorganize all information related to a concept on one page.	0 (0)	10 (14)	61 (86)	4 (4 – 5)
8	I anticipate the time I spend studying this material outside class to be less than traditional lectures.	23 (32)	11 (16)	37 (52)	4 (2 – 4)
9	I would like additional lectures to be presented in this format.	4 (6)	15 (21)	52 (73)	4 (3 – 5)

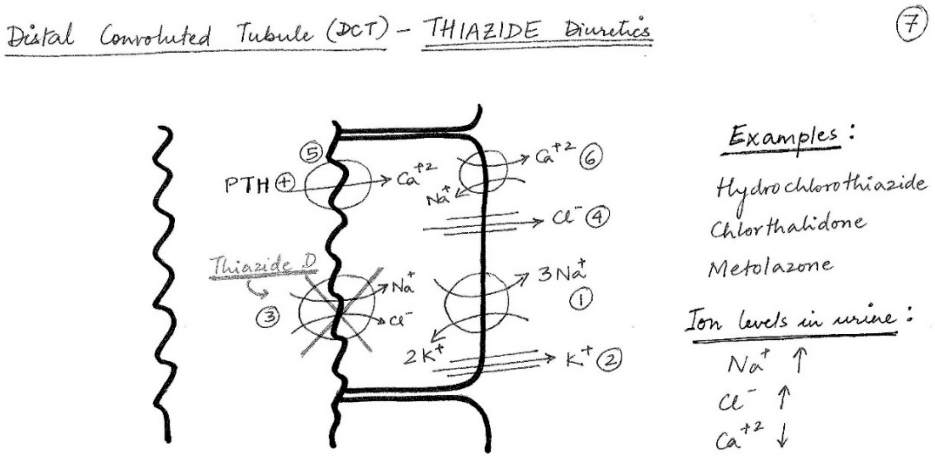
[a]SD: Strongly disagree; D: Disagree; N: Neutral; A: Agree; SA: Strongly agree [b]IQR: Interquartile range

Figure 1. Sample blank workbook page depicting a diagram skeleton and table for compiling information on the thiazide subclass of diuretics, based on the normal physiology in the distal convoluted tubule (DCT) of the nephron.



Mechanism	Uses	Adverse effects

Figure 2. Sample instructor-completed workbook page depicting a completed diagram and table compiling information on the normal ionic movements and transporters involved in the DCT, common drug examples, mechanism of action and related clinical uses and adverse effects for the thiazide subclass of diuretics.



Mechanism	Uses	Adverse effects
1. Diuretic	Hypertension	Compensatory rise in BP
2. K^+ - wasting		Hypokalemia
3. ↓ Ca^{+2} in urine	Nephrolithiasis	Hypercalcemia
4. Competes with OAT		Hyperuricemia
5. Inhibits insulin		Hyperglycemia
6. ↑LDL, ↑cholesterol		Dyslipidemia
7. Chemical structure		Sulpha - allergy