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HOW WE TEACH | *Classroom and Laboratory Research Projects*

Digital chalk-talk videos improve knowledge and satisfaction in renal physiology

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[1]*Division of Nephrology, Department of Medicine, Duke University School of Medicine, Durham, North Carolina;* [2]*Division of General Internal Medicine, Department of Medicine, Duke University School of Medicine, Durham, North Carolina;* [3]*Office of Curricular Affairs, Duke University School of Medicine, Durham, North Carolina;* [4]*College of Osteopathic Medicine, University of New England, Portland, Maine; and* [5]*College of Osteopathic Medicine, William Carey University, Hattiesburg, Mississippi*

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Roberts JK, Chudgar SM, Engle D, McClain EK, Jakoi E, Berkoben M, Lehrich RW. Digital chalk-talk videos improve knowledge and satisfaction in renal physiology. *Adv Physiol Educ* 42: 146–151, 2018; doi:10.1152/advan.00131.2017.—The authors began a curriculum reform project to improve the experience in a Renal Physiology course for first-year medical students. Taking into account both the variety of learning preferences among students and the benefits of student autonomy, the authors hypothesized that adding digital chalk-talk videos to lecture notes and live lectures would improve student knowledge, course satisfaction, and engagement. The authors measured performance on the renal physiology exam before (the traditional curriculum) and for 2 yr after implementation of the new curriculum. During the traditional and subsequent years, students took a Q-sort survey before and after the Renal Physiology course. Satisfaction was assessed based on ranked statements in the Q sort, as well as through qualitative analysis of student commentary. Compared with the traditional curriculum, mean scores on the renal physiology final exam were higher after implementation of the new curriculum: 65.3 vs. 74.4 ($P < 0.001$) with *year 1* and 65.3 vs. 79.4 ($P < 0.001$) in the second year. After the new curriculum, students were more likely to agree with the statement, "I wish other courses were taught like this one." Qualitative analysis revealed how the video-based curriculum improved student engagement and satisfaction. Adding digital chalk-talk videos to a traditional Renal Physiology course that included active learning led to improved exam performance and high levels of student satisfaction. Other preclinical courses in medical school may benefit from such an intervention.

curriculum; medical student; physiology; renal; video

INTRODUCTION

The medical education paradigm is evolving to account for changing attitudes toward learning medical knowledge and professional development. A recent expert evaluation recommended standardized learning outcomes, an individualized learning process, and classrooms that better integrate the clinical experience (7). Although the optimal preclinical curriculum has yet to be defined, one clear trend in undergraduate medical education reform is the inclusion of more active learning strategies and the adoption of electronic learning resources.

Thus the classroom has been modified by including more active learning strategies and incorporating principles of adult learning theory in a variety of formats (4, 9, 12). While medical school curricula keeps pace with changing models of instruction, student preferences have also evolved. Many students avoid live lectures, but some students prefer to attend all lectures, whereas the rest use a number of factors to determine attendance (2, 3, 6). In a pilot Q-sort study of attitudes across a wide variety of topics, we found that students in our Renal Physiology course segregated themselves best according to learning preferences: some prefer attending live lectures, some prefer reading texts, and some prefer watching digital videos (15). Since students themselves are ultimately responsible for learning, it is worth recognizing that different students have different preferences for how to acquire medical knowledge, most of which will take place outside of the classroom. As we embarked on a curriculum reorganization process for our Renal Physiology course, a paradigm shift was occurring in medical education, such that schools were placing a greater emphasis on active learning strategies and team-based exercises across the preclinical curricula. In particular, the Stanford Medicine Interactive Learning Initiative began to develop a library of short digital videos for acquisition of foundational knowledge, and then proposed using class time for active learning and knowledge application (13). After implementation of a series of springboard videos, course evaluations and focus group responses found that the majority of students favored using the digital videos, and some reported enhanced engagement and retention (1). While some students seem to respond favorably to short digital videos, it remains unclear how these videos impact actual learning outcomes.

While our Renal Physiology course already included active learning and team-based exercises, foundational knowledge was delivered primarily through live lectures and course notes. We wanted to better understand the impact of adding new digital chalk-talk videos to the course, while emphasizing interactive, clinically oriented classroom sessions. We named this the Modal curriculum, because the foundational course content was replicated across many forms as we continued to provide traditional live lectures and course notes, in addition to

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the newly created digital videos. We hypothesized that this curriculum would improve student satisfaction and performance on the final examination.

METHODS

We conducted our study during 3 academic years at Duke University School of Medicine. Our target audience was a convenience sample of first-year medical students enrolled in a required course that includes organ-based modules on anatomy, histology, and physiology. In the academic year 2013–2014 (traditional curriculum), the class comprised 113 students. Our intervention occurred in the 2014–2015 (108 students) and 2015–2016 (115 students) academic years.

The traditional Renal Physiology course included live lectures on glomerular filtration, tubular reabsorption, regulation of body fluid osmolality, regulation of extracellular fluid volume, acid-base physiology, and potassium homeostasis. Attendance was not mandatory, and all live lectures were video recorded and available for online viewing. Active learning sessions included an introduction to physiology involving a patient interview, one clinical application about diuretics, one clinical application session about hyponatremia, and a team-based exercise involving cases of hyperaldosteronism.

The Modal Renal Physiology course was implemented in the two subsequent academic years. The fundamental course content was identical to that in the control curriculum. In addition to live lectures, course notes, and video recordings of live lectures, they had access to new digital chalk-talk videos (blackboard-style, narrated videos that heavily use diagrams and cartoon drawings) (16). The digital chalk-talk videos, also known as "pencasts," were authored by Renal Physiology course instructors (J.K.R. and M.B.) and hosted on a Vimeo channel specifically created for the renal physiology module. The videos were constructed in the style of Khan Academy video tutorials, with the instructor both narrating and drawing freehand on a digital tablet (8). We reorganized the broad, core topics into a series of 6- to 12-min videos. We chose this length and format based on the available evidence for maximizing student engagement with online videos (5, 14). Each major topic was covered by 2–4 videos, resulting in a total of 13 videos. The digital videos were identical in depth and scope to course content compared with the lectures and lecture notes. All of the course notes and videos were simultaneously accessible at course start. Course notes for each topic were updated to better mirror the content as presented in the lectures and videos. Live lectures with optional attendance were scheduled in a sequence identical to the traditional year curriculum.

The Modal curriculum also included mandatory-attendance interactive, clinical application sessions like the traditional year, but with one exception: the addition of a single large-group, interactive simulation experience utilizing SimMan technology. This was a team-based experience where teams of students made clinical decisions through multiple-choice questions using an audience-response system.

We assessed knowledge of renal physiology by performance on an examination covering two physiology sections: renal physiology and gastrointestinal (GI) physiology. The Normal Body course director was ultimately responsible for the examination content and administration. During the control curriculum, this exam contained 23 renal questions and 21 GI questions. During the first Modal curriculum year, the exam contained 32 renal questions; 21 were identical to questions used in the control year. During the second Modal curriculum year, the exam contained 27 renal items, 16 that were identical to questions used in the prior years. All exam questions were high-quality, multiple-choice, single-best-answer-style questions. During the 2015–2016 examination, one GI and one renal question were removed from final grading as well as from our analysis. No other items were questioned by students or removed from grading. Examinations were administered electronically in a highly secure manner, and no instances of student misconduct or cheating were reported in the Normal Body course during our study period. Also, no major curricular changes were introduced to the GI physiology curriculum and examination during the time of our study.

We assessed satisfaction and learning behaviors using a pre- and postcourse assessment of student attitudes using a hybrid quantitative-qualitative survey technique called a Q sort, whereby students rank a set of pre-prepared statements into columns rated from strongly disagree (−4) to strongly agree (+4). We delivered this survey using FlashQ (version 1.0, Hackert and Braehler, Germany), a web-based program designed to both administer a Q sort and electronically record the data. We invited students to take the survey on the first and final days of their renal physiology module. Participation in this survey was voluntary. Within FlashQ, students have the option to provide written commentary in response to the most agreed and disagreed statements selected from the statement set. We also measured the utilization of the various resources in the Modal curriculum by recording attendance at nonmandatory lectures, the number of downloads for course notes, and the number of video views after the start of the course. The Duke University and University of New England Institutional Review Board deemed this study exempt from review.

We conducted all quantitative analyses in SAS Enterprise Guide, version 5.1 (SAS, Cary, NC) and STATA, version 14.0 (Statacorp, College Station, TX). Continuous data are reported as means ± SD. For continuous data, we used one-way ANOVA, followed by a post hoc comparison of means using *t*-tests. For ordinal data, we used the Kruskal-Wallis test to test for an overall difference among group medians and the two-sample Mann-Whitney test for follow-up pairwise comparisons. To account for multiple comparisons of follow-up tests, a Bonferroni correction was used in pairwise comparisons.

We obtained commentary in response to the two most agreed on statements and two most disagreed on statements from the statement set of the survey. For this analysis, we isolated and analyzed only commentary related to course characteristics and student satisfaction. One of the investigators (J.K.R.) reviewed all comments for accuracy and legibility. Using a grounded theory approach, the core coding team (J.K.R. and S.M.C.) independently read the comments and performed open coding in isolation. Lengthy comments were separated into discrete sentences so that distinct ideas could be independently coded. The coding team met regularly to resolve discrepancies and review the code structure. We combined related codes in an iterative process until there was full agreement between the coders to produce a final codebook. Codes were refined until we identified all of the major themes in the data. After this, we applied this structure to all of the student comments. Finally, an independent researcher (E.K.M.) with experience in qualitative methods reviewed the coding process and analysis of themes. No discrepancies or misinterpretations were identified in either the coding structure or in the final themes.

RESULTS

In the Modal curriculum, attendance for nonmandatory live lectures ranged from 35 to 44% for each topic, consistent with our typical attendance for nonmandatory lectures of 30–40%. Course note downloads ranged from 71 to 85 per topic. Video views ranged from 98 to 264 per topic. We were unable to account for the number of video views for unique students; therefore, multiple views by a single student would count as separate views. Table 1 shows the utilization for each resource.

Mean scores on renal physiology exam questions differed among the groups we studied ($P < 0.0001$). Compared with the traditional year, mean scores were significantly higher in the first year of the Modal curriculum [65.3 (SD 10.7) vs. 74.4 (SD 10.2), $P < 0.001$] and in the second year of the Modal curriculum [65.3 (SD 10.7) vs. 79.4 (SD 10.8), $P < 0.001$] (see Fig. 1).

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Table 1. *Utilization of course resources during the Modal curriculum in 2014–2015*

Topic	Lecture Attendance, *n* (%)	Course Note Downloads, no.	Pencast Video Views, no.
Glomerular filtration	47 (44)	85	264
Tubular reabsorption	47 (44)	84	154
Regulation of body fluid osmolality	38 (35)	71	103
Regulation of body fluid volume	35 (32)	73	107
Acid base	37 (34)	72	115
Potassium	37 (34)	74	98

Lecture attendance values are *n*, no. of students (with percentage in parentheses).

From year to year, the final examination was modified according to the course director's discretion. Therefore, we analyzed mean scores of only exam items that were common to both exams, and again differences existed among the groups we studied ($P < 0.0001$). We observed significantly higher mean scores in students exposed to the Modal curriculum (see Fig. 2) in Modal *year 1* [64.4 (SD 11.7) vs. 72.7 (SD 10.0), $P < 0.001$] and Modal *year 2* [71.0 (SD 11.0) vs. 76.1 (SD 11.8), $P < 0.001$].

Compared with mean scores on GI physiology exam questions, mean renal physiology scores were lower during the traditional curriculum. In the following years, mean scores on GI physiology questions were higher during both Modal *year 1* [75.8 (SD 9.9) vs. 81.74 (SD 8.3), $P < 0.001$] and Modal *year 2* [75.8 (SD 9.9) vs. 79.1 (SD 9.2), $P < 0.008$] compared with the traditional year. We calculated the mean difference in scores between each student's performance on renal and GI examination items. We observed statistically significant differences between the renal-GI score difference between the groups in our study ($P < 0.0001$). Compared with the control year, the difference in scores on renal and GI items decreased after implementation of the Modal curriculum (see Fig. 3). The mean difference between renal and GI scores decreased during Modal *year 1* (11.1 vs. 7.0; $P < 0.006$) compared with the traditional year. By Modal *year 2*, performance on the GI and renal exams was similar, and this was significantly different from that in the traditional year (11.1 vs. 0.2; $P < 0.001$).

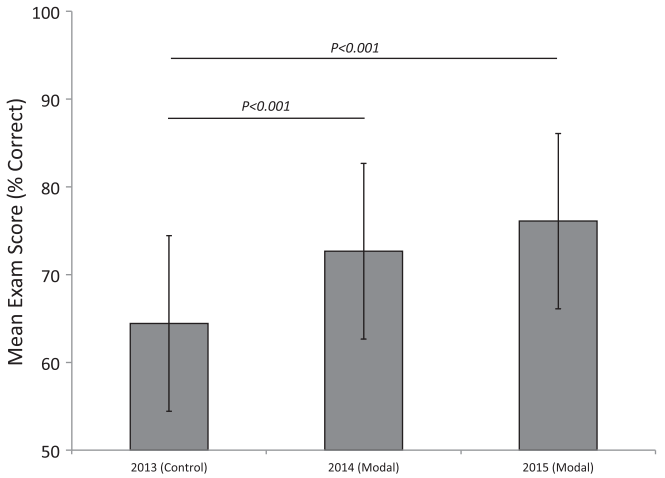

Fig. 2. Comparison of mean scores on common final examination questions between the traditional and Modal courses. Values are means ± SD.

During the traditional year and Modal *year 1*, students were invited to participate in the attitudes survey. During the traditional year, 60 surveys (53%) were submitted before the course, and 23 surveys (20%) were submitted after the course. In Modal *year 1*, 46 precourse surveys (43%) were submitted, and 44 postcourse surveys were submitted (41%). Within the Q-sort statement set, we identified which statements related to course satisfaction. The median sort score was calculated for each statement both before and after the course. The sort score was a number ranked on a scale from −4 (strongly disagree) to 4 (strongly agree). Table 2 shows agreement with select statements before and after the course during both the traditional and Modal years. There was a statistically significant difference in agreement with the statement, "I wish other courses were taught like this one" between the traditional year and Modal year students' postcourse survey responses ($P < 0.0001$).

Qualitative analysis of commentary related to student and course satisfaction showed many differences between experiences in the traditional year and Modal year. Representative quotes from students in the traditional and Modal years are found in Table 3. In both student cohorts, students recognize

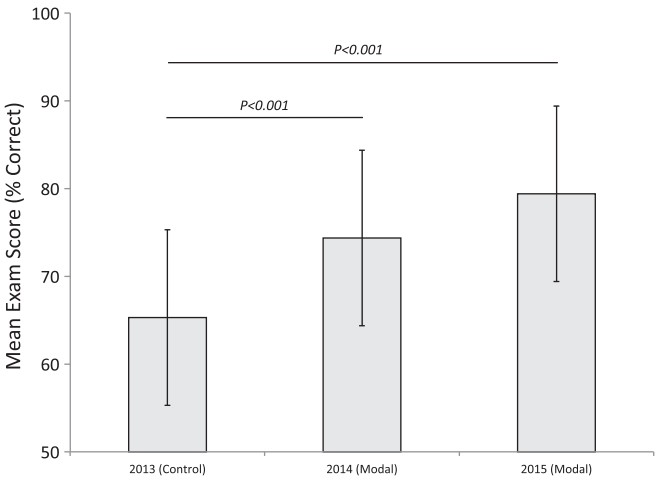

Fig. 1. Comparison of mean scores on all final examination questions between the traditional and Modal courses. Values are means ± SD.

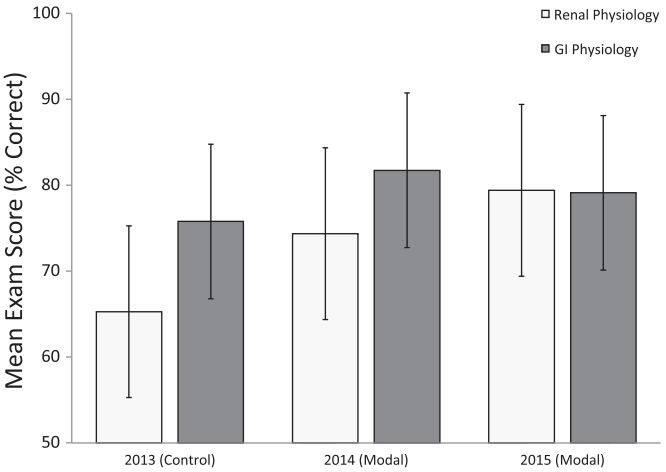

Fig. 3. Comparison of performance on renal physiology final exam with GI physiology final exam scores. Values are means ± SD.

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Table 2. *Agreement with statements about course satisfaction pre- and post-renal physiology in a traditional format and modified format*

Statements Related to Course Satisfaction	2013–2014, Traditional		2014–2015, Modal *Year 1*		*P* Value
	Pre	Post	Pre	Post	
n	60	23	46	44	
Our lectures are stimulating					0.57
Median (IQRs)	0 (1.25)	0 (1.5)	0 (2)	0 (2)	
Mean (SD)	0.15 (1.36)	−0.17 (1.53)	−0.15 (1.59)	0.14 (1.23)	
Our instructors don't seem to enjoy teaching					0.35
Median (IQRs)	−2 (2)	−3 (1.5)	−3 (2)	−3 (2)	
Mean (SD)	−2.3 (1.3)	−2.26 (1.8)	−2.56 (1.39)	−2.7 (1.32)	
Physiology is easier than other courses					0.92
Median (IQRs)	−2 (1.5)	−1 (2)	−2 (2)	−1.5 (2.25)	
Mean (SD)	−1.28 (1.77)	−1.22 (1.59)	−1.3 (1.74)	−1.45 (1.55)	
The school supports students with different learning styles					0.06
Median (IQRs)	2 (2)	1 (2.5)	1 (2)	2 (2)	
Mean (SD)	2.03 (1.43)	1.35 (1.61)	1.35 (1.46)	1.55 (1.49)	
Our lectures are well organized					0.06
Median (IQRs)	0 (1.25)	0 (3)	0 (1)	1 (2)	
Mean (SD)	0.3 (1.61)	−0.39 (1.75)	0.2 (1.42)	0.75 (1.43)	
All of my questions get answered					0.57
Median (IQRs)	0 (2)	0 (2)	0 (2)	0 (2)	
Mean (SD)	0.22 (1.65)	−0.35 (1.89)	−0.22 (1.66)	0.07 (1.21)	
I wish other courses were taught like this one					0.0001
Median (IQRs)	0 (1)	−1 (1)	0 (1.75)	1 (3)	
Mean (SD)	−0.47 (1.05)	−0.57 (1.59)	0.11 (1.14)	1.34 (1.96)	
I have enough to time to keep up with everything					0.16
Median (IQRs)	−1 (3)	−1 (2)	−1 (2.75)	−1 (3)	
Mean (SD)	−1.43 (1.92)	−0.96 (2.0)	−0.78 (2.17)	−0.61 (1.73)	

n, No. of students. Both means (standard deviation, SD) and medians (interquartile ranges, IQRs) are reported. Agreement is ranked on a scale from −4 (strongly disagree) to + 4 (strongly agree).

that the instructors are enthusiastic and generally seem to enjoy teaching. Otherwise, we found diverging themes between students in the traditional and Modal courses. In the traditional course, students highlight how easy it is to fall behind in class due to the volume of material and the pace of medical school. Many students also thought the lectures felt rushed and student questions were not directly answered. In response clinical correlation sessions, the students were frustrated with understanding the case without enough baseline knowledge required to interpret it correctly. This issue left students frustrated, but there was also a general sense that the course itself was disorganized.

In the Modal course, students recognized the time, energy, and investment required for the new course, which led to better student engagement. Students appreciated the additional learning resources, which led to improved exam performance. Specifically, the digital chalk-talk videos were singled out as high-quality, visual resources that supplemented or replaced other learning methods. The students in the Modal cohort thought the course was well organized in a logical and coherent manner. The students predominantly thought that the format of the course should be replicated and digital chalk-talk videos should be created for other courses.

DISCUSSION

In this study, we examined the impact of adding digital chalk-talk videos on exam performance and satisfaction in a Renal Physiology course. Compared with a traditional course format that included active learning, we observed a significant increase in exam performance following the addition of our videos. In a subsequent academic year with a new cohort of students, this effect persisted. Because the renal physiology exam changed slightly over time, we measured performance on only shared examination questions between the Modal and traditional years, and we still observed a significant increase in scores with the Modal curriculum. To account for differences in test-taking abilities, test day circumstances, or other unmeasured variables, we compared performance on renal physiology questions with GI physiology questions that were administered on the same day. It should be emphasized that no curricular changes were introduced to the GI physiology curriculum during the time of our study. In the traditional year, mean scores on the GI exam were higher than on the renal exam, but in the Modal years, renal physiology scores improved to the point where there was no difference in performance between the two subsections. While exam performance may vary from year to year due to variance in each class, this suggests that the observed improvements in renal physiology exam scores could be attributable to our curricular changes.

Regarding course satisfaction, we allowed students to rank a number of statements related to course satisfaction. After our Modal Physiology course, students were significantly more likely to agree with the statement "I wish other courses were taught like this one," compared with the traditional year. In addition, we found that students in our Modal course had more favorable opinions of the course compared with the traditional course. Some respondents in the traditional course found it disorganized and confusing, whereas respondents in the Modal course felt it was well organized. This is interesting in light of the fact that course instructors, live lectures, content, and sequencing were identical between the two. In light of student commentary (see Table 3), one explanation is that adding

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Table 3. *Themes and illustrative quotes from commentary written by medical students after traditional and Modal renal physiology*

Themes	Sample Quotations
Traditional course	
The renal physiology course instructors are passionate, enthusiastic, and clearly enjoy teaching.	"Lectures were not organized, at least not in any way that I could figure out." "Most passionate teachers that I have seen."
In the traditional course, the lectures felt rushed, and many questions were left unanswered, which frustrated students.	"Professors should not lead with a case if we have NO concept of renal physiology."
The traditional course was disorganized and confusing.	"Can't ask us to interpret lab values when we have not learned the underlying physiology yet." "Important ideas were not explained." "Every class I attended made me more confused." "Rushed through material." "Questions that were pushed off or were unknown by the professor."
Modal course	
The instructors clearly invested more time and energy into the course, which made the material more interesting and enhanced student engagement.	"I think that I was more engaged in the lectures and with the material as the result of this investment by the professors. If more courses/sections were like this it would be outstanding!"
Modal course catered to individual learning.	"I think the instructors of this course have done an amazing job of supplying students with a variety of resources, and have made it clear that they want students to learn in the way that is most effective for them."
Videos were singled out as high-quality resources that were heavily utilized.	"I am more of a kinetic learner so the pencasts were amazing for me. I went through all of them and followed along with the drawings, looking up points that I wanted to learn more about as I went."
Course well organized in a logical manner.	"I really appreciate the videos and the coherence of this course. It was very important for me to be exposed to the concepts as many times as possible, so being able to watch the videos, then come to lecture, then go over the concepts in cases was very useful."
The students want this course format replicated for other course.	"The lectures go in an order that are [sic] not all over the place but have a great way of building on one another." "I really enjoyed the pencasts and I think those would be a great addition to the other physiology topics as well." "The pencasts were amazing. I wish every system would have those."

The methods for the Q-sort survey and one student comment were published in Roberts et al. (17).

concept videos has additional positive effects that go beyond information transfer. We would suggest that introducing a new curricular structure with a menu of learning options demonstrated the instructors' commitment to individualized learning, which may have led to student buy-in early in the course. This boost in engagement and interactivity led to improved enthusiasm for the material, which in turn led to improved performance on the examination.

Our study is not without limitations. First, our cohorts consisted of convenient samples of medical students taking the Normal Body course during a planned curricular change. Because the student cohorts differed from year to year, it is possible that differences in class demographics or academic achievement were present and not accounted for in the final analysis. However, during the years of our study, the admission criteria for Duke School of Medicine did not change. Also, while our school does not publicly disclose academic demographics for each matriculating class, the average college grade point average and admission MCAT scores were statistically similar among all of the classes included in our study. Regarding course utilization metrics, we were limited to measuring lecture attendance, course note downloads, and unique video views. We were unable to more accurately measure engagement at the individual student level. The qualitative analysis, however, does suggest the wide variety of course resources were well utilized. Regarding our survey, participation was voluntary, and our response rates ranged from 20 to 53%. It is possible that the respondents were students with either overly positive or negative opinions, which may not reflect each class as a whole. Regarding student engagement, it is unclear if the announcement of a novel curriculum itself led to the increase in student engagement, or if this was the result of the actual curricular change. However, in the second year of the Modal curriculum, we continued to see improved performance and student satisfaction, supporting the primary effect of the curriculum itself. Lastly, a single team-based exercise during the traditional year (focusing on hyperaldosteronism) was replaced by a hyperkalemia team-based exercise in the Modal years. This change occurred outside of this study and could be a potential confounding variable. However, the impact on our analysis is minimal or absent in that we observed the same trend in scores when analyzing only exam questions common to both the traditional and Modal years, thus removing any effect this new session could have on learning outcomes.

As medical schools attempt to keep pace with changing attitudes and innovations in technology, the optimal learning platform may include a variety of interchangeable, high-quality learning resources like a library of digital chalk-talk videos. The advantage of the chalk-talk video is that it enables the student to follow development of a concept and its application at a customized pace, personally guided by the instructor. These videos are well utilized by students and appear to help

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them prepare for active learning sessions, where they can apply their knowledge to clinical scenarios. In our Modal curriculum, students were encouraged to choose their own individualized path through the core material, which perhaps led to the increase in course satisfaction and desire to replicate this model for other preclinical classes. In this format, students could choose to "flip" the classroom, by viewing videos before classroom or clinical correlation sessions (10, 11, 18). Giving students a menu of learning options (identical content shared across formats) that includes digital chalk-talk videos allows them to personalize the learning process. This paradigm was associated with a significant improvement in final examination scores and satisfaction in our Renal Physiology course. Such an initiative across medical schools nationwide might improve knowledge and general satisfaction during the preclinical years of medical school.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

J.K.R., E.M., E.J., M.B., and R.L. conceived and designed research; J.K.R. and R.L. performed experiments; J.K.R., S.M.C., and D.E. analyzed data; J.K.R., S.M.C., E.M., E.J., and R.L. interpreted results of experiments; J.K.R. prepared figures; J.K.R. drafted manuscript; J.K.R., S.M.C., D.E., E.M., E.J., M.B., and R.L. edited and revised manuscript; J.K.R., S.M.C., D.E., E.M., E.J., M.B., and R.L. approved final version of manuscript.

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