Patterns of medical student engagement in a second-year pathophysiology course: relationship to USMLE Step 1 performance

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Kauffman CA, Derazin M, Asmar A, Kibble JD. Patterns of medical student engagement in a second-year pathophysiology course: relationship to USMLE Step 1 performance. *Adv Physiol Educ* 43: 512–518, 2019; doi:10.1152/advan.00082.2019.—Historically, attendance has been a marker of academic performance, but the current medical education literature has had mixed results. In addition, attendance is dropping in the preclinical curricula, whereas, at the same time, the focus on United States Medical Licensing Examination Step 1 performance is increasing. This present study is a mixed-method approach correlating student attendance and access to the formal curriculum in a second-year pathophysiology course to performance on Step 1. Additionally, survey and focus group data evaluated the usage and importance of both the formal curriculum and third-party resources. Out of 112 eligible students, 77 participated in the study. There was no correlation between attendance or access to the learning materials and Step 1 performance. There was a strong correlation between the performance on the final examination and that of Step 1 ($r = 0.813; P < 0.001$) and a moderate correlation between formative quiz ($r = 0.321; P = 0.005$) and individual readiness assessment test performance ($r = 0.351; P = 0.002$) and Step 1 performance. Survey and focus group data show that students place high importance on faculty-developed materials that they can use on their own, but not attendance. The third-party resources are highly used as an adjunct to the formal curriculum and to focus on Step 1 study. Attendance and access to the formal curriculum do not predict Step 1 performance, whereas performance on high- and low-stakes internal assessments do. Further study on how the lack of social interaction gained from attendance affects development of other competencies and the learning climate are warranted.

classroom attendance; medical education; student engagement; USMLE Step 1

INTRODUCTION

Attendance at classroom sessions has commonly been used as a marker for student engagement. Large-scale studies have previously shown that attendance is a marker for course performance in undergraduate students (6). However, these studies were completed before the common practice of providing learning materials online and the availability of multiple third-party resources on the internet. The recent literature in medical education on this has been mixed (8, 9, 21, 22). Programs where the materials were not available to students unless they attended class showed a connection between attendance and performance (8, 22). The converse was seen in studies in which materials were available online, regardless of student attendance (9, 21). In our own program, all lectures are recorded and made available online as well as all other learning materials. In a recent study, we showed that attendance was not a marker of examination performance in a second-year pathophysiology course (15). Classroom attendance has been declining at medical programs across the US (4, 13, 23). This is likely due, in part at least, to the competing demands for student attention with third-party resources used to prepare for the United States Medical Licensing Examination (USMLE) Step 1. Although designed to be a pass/fail exam for licensure, the reported 3-digit score has been widely used for other purposes, including screening for residency selection (20). This score affects a student’s ability to apply for the specialty of his/her choice, as more competitive specialties and competitive programs within a specialty require a higher Step 1 score (11, 19).

Most medical programs have a dedicated period for Step 1 study set aside for the students at the end of the preclinical curriculum. However, Burk-Rafel et al. (3) demonstrated that the majority of students begin this dedicated focused study for Step 1 before the end of the second year, with some actually beginning this during their first year. Students are focusing their attention on commercial Step 1 preparation materials at the expense of the formal curriculum. This leads to contention between faculty and the students when materials that are perceived as not directly relevant to Step 1 are covered in this time frame (4). Burk-Rafel et al. (3) also demonstrated that third-party resources were the predominant source for study materials for Step 1, with over 99% of students surveyed using them (3).

With this declining attendance, its lack of correlation to performance, and the competing demands for the student’s attention with third-party resources, we wanted to evaluate how the usage patterns of the formal curriculum (i.e., attendance as well as accessing of faculty-developed materials) were associated with examination performance within our program, as well as on future performance on Step 1. The University of Central Florida (UCF), College of Medicine (COM) has an integrated curriculum that begins the preclinical portion with normal processes, followed by a systems-based division of pathophysiology and pharmacology. Running in parallel to, and integrating with, the basic sciences modules is a course emphasizing clinical skills (e.g., professionalism, communication and interpersonal skills, and clinical reasoning). A 6-wk Gastrointestinal and Renal Systems (GI/Renal) Module was selected for study because it occurs approximately
halfway through the second year of our curriculum when the students are likely managing preparation for Step 1 alongside the formal curriculum.

**METHODS**

Participants and recruitment. Eligible participants were the 114 students enrolled in the GI/Renal (S4) Module in the 2017–2018 academic year. The study was presented to the students during the mandatory module orientation on the first day of the course. Students were assured that no identifiable data collected during the study would be available to the module director, and that participation in the study would have no effect on the module grade. Consent was obtained through a single question electronic survey (Qualtrics, Provo, UT). Compensation was not given for the attendance and performance data collection. However, participants who agreed to participate in the survey and/or focus group components were compensated for their time with $10 per hour (1 h each for survey and focus groups). This study was approved by the UCF Institutional Review Board (SBE-14–10344).

Pedagogy and attendance policy. Multiple different types of pedagogies (with relative percentages of course time) were used in the module, including lecture (49%), small-groups cases (17%), application exercises (15%), online self-learning modules (SLM; 8%), and team-based learning (TBL; 11%). Lectures had variable amounts of interactivity, such as multiple-choice questions using an audience response system and think-pair-share, based on the individual lecturer’s style. All lectures were video recorded and made available to the students after the session was complete through the online learning management system. The COM uses Canvas (Instructure, Salt Lake City, UT) for its online learning management system, which the university has rebranded as Webcourses. Similarly, all other learning artifacts were provided online, including lecture PowerPoint files, SLMs, and case answers. Students do not have access to prior year’s materials through Webcourses.

Case-based learning exercises were divided into two types, based on the content covered: small-group cases and application exercises. Small-group cases included content either that was not covered elsewhere, or if there was a significant new clinical perspective. These were sessions with mandatory attendance, and students worked in a group that was randomly assigned by the module coordinator at the beginning of the course. Application exercises were defined as activities based on material that was also covered in lecture or SLM; attendance was voluntary, and students worked in groups of their own choosing. Both types of case-based learning exercises were otherwise of a similar structure in that clinical case presentations were followed by a series of predetermined questions and presented in a web-based interactive platform KuraCloud (Li, ADInstruments, Colorado Springs). Faculty members were available to answer questions and guide student’s discussion as needed. After each session was complete, faculty answers were released to all students.

The standard COM attendance policy for instructional sessions was followed during the module. All TBL and small-group cases had mandatory attendance. Attendance at lecture and application exercises was at the discretion of the individual student. The students were responsible for all material presented in the module, regardless of whether or not there was required attendance. Attendance at all sessions was recorded at the beginning of each session using a Bluetooth-enabled smart phone application, TealPass (Nashville, TN).

Assessment. Formative assessment consisted of five weekly multiple-choice question quizzes with predetermined answer feedback. Each quiz was made available at the end of that week’s instructional sessions through Webcourses and remained available for the remainder of the course. There were no limitations to the number of attempts for each quiz. They ranged in length from 7 to 28 questions (average 18), depending on how much material was presented during that week.

Summative assessment consisted of the four TBL individual/group readiness assessment tests (IRAT/GRAT; 4% each), a longitudinal small-group case report (4%), and the final examination (80%). The final, summative examination consisted of 118 multiple-choice questions based on material presented in all session types. The projected mean on the exam based on historical performance was 85%. The questions were written by the faculty in the course in National Board of Medical Examiners (NBME) style with a clinical vignette and requiring the application of knowledge to come to a single, best answer.

Surveys and focus groups. Students who consented to the study were invited to complete an electronic survey (Qualtrics, Provo, UT), which obtained their opinion on the importance of course resources and their usage of third-party resources. They were asked, “How important are each of the following course resources to your learning?” (lecture PowerPoint files, SLMs, in-person live lectures, recorded lectures, in-person case-based learning sessions, clinical case answers, TBL sessions, recommended reading assignments). A 7-point Likert scale was used with the following anchors: 7 = “essential to my learning” and 1 = “not important for my learning.” For third-party resources, they were asked, “Do you utilize any additional medical education outside resources (not developed by UCF COM faculty) to supplement your learning during the S4 [GI/renal] module?” They were then supplied with a list of the third-party resources most commonly seen in use at the COM by the authors: “Please check all applicable outside resources that you have utilized, or expect to utilize, to supplement your learning in the S4 GI/Renal module.” They were also given an open comment box that allowed them to add additional resources not on the provided list.

Participating students were invited to one of three focus groups based arbitrarily on their attendance levels in the first 2 wk of the course: High attenders (>50%), medium attenders (10–50%), and low attenders (<10%). Focus groups explored the perceived advantages and disadvantages of attendance, what aspects of each learning modality were seen as effective or ineffective, what other factors influenced the decision to attend or not, and how outside learning resources and other priorities influenced course engagement. The focus groups were led by a fellow student (author M.D.) and audio recorded. All recordings were transcribed for thematic analysis. Focus group transcripts were independently coded by three investigators, who then met to reach consensus on the major themes.

Data collection and statistics. All documents related to a session (e.g., PowerPoint files, SLMs, and/or faculty answers) were linked to the calendar entry for that session in the learning management system (Webcourses). Each time a student clicks on any link in the module, the system automatically records it with a time stamp. If it was an interactive file housed in the system (e.g., videos and quizzes), then the time spent on each activity was also recorded. Lecture PowerPoint files and videos were housed separately in the system, and their usage was recorded independently. At the end of the module, this event record was exported as an Excel file, giving a record of each student’s interaction with all material accessible through the system. Data were de-identified and linked to the final exam and USMLE Step 1 score by the COM Office of Assessment.

Classroom attendance as well as the rates of usage of curriculum materials, quiz scores, and the final examination score are expressed as percentages; data are reported as median and range (means with SD have also been included). The USMLE Step 1 score was expressed using the 3-digit score provided by the NBME. Spearman’s correlation coefficients were calculated to assess the relationships between the USMLE Step 1 score and classroom attendance, use of curriculum materials, formative quiz scores, TBL IRAT scores, and the final examination score. Likert scores for the utility of curriculum resources were compared using a Kruskal–Wallis analysis of variance with follow-up pairwise Mann–Whitney U tests to locate inequalities; Bonferroni correction for multiple comparisons was applied.
**Table 1. Curricular material and quiz usage correlated with both final examination and Step 1 performance**

| Curriculum materials                      | Mean (SD) | Median (Range) | Correlation to Final Examination | P Value | Correlation to Step 1 Performance | P Value |
|------------------------------------------|-----------|----------------|---------------------------------|---------|----------------------------------|---------|
| Lecture video viewing, %                 | 60.6 (39.4)| 62.1 (0–182)   | 0.138                           | 0.23    | 0.035                            | 0.76    |
| Total lecture consumption, %             | 85.0 (35.1)| 92.9 (0–210)   | −0.008                          | 0.94    | −0.033                           | 0.78    |
| Self-learning modules viewing, %         | 59.7 (39.3)| 63.4 (0–217)   | −0.119                          | 0.31    | −0.214                           | 0.06    |
| Artifacts accessed, %                    | 67.8 (31.1)| 77.6 (1.5–100) | 0.17                           | 0.13    | 0.129                            | 0.26    |
| IRAT score, %                            | 86.5 (8.3) | 87.5 (67.5–100)| 0.500                          | <0.001* | 0.351                            | 0.002*  |

**Formative quizzes**

| Quizzes taken on time, %                 | 43.3 (31.0) | 40 (0–100)   | 0.159                          | 0.17    | 0.116                            | 0.31    |
| Quizzes taken, %                         | 94.0 (20.3) | 100 (0–100)  | 0.013                          | 0.91    | 0.004                            | 0.97    |
| Total attempts, no.                      | 8.0 (3.9)   | 7 (0–26)     | −0.017                         | 0.88    | −0.046                           | 0.69    |
| Mean score of first attempts, %          | 75.6 (8.1)  | 76.7 (54.8–89.5)| 0.416                          | <0.001* | 0.321                            | 0.005*  |

n = 77 Students. IRAT, individual readiness assessment test. *Percentage out of 2,000 possible minutes. Sum of percentage of lecture attendance and lecture video minutes viewed. SD, percentage of the 67 total available artifacts accessed by the students (includes lecture and self-learning module PowerPoint files, faculty answers for the mandatory small-group case-based learning sessions, and application exercises). Cumulative score on all 4 IRATs in the course; each IRAT was out of 10. Percentage of the 5 weekly formative quizzes taken at any time before the end of the week until classes resumed the next week. *Percentage of the 5 weekly formative quizzes taken at any time before the end of the module. Summation of the total number of attempts on all 5 quizzes. *Percentage of all 5 weekly formative quizzes; quizzes ranged in length of 7–28 items, depending on the amount of material covered that week. *Significant correlation.

**RESULTS**

*Attendance and objective curriculum usage.* Of the 114 students registered for the GI/Renal Module during the 2017–2018 academic year, 112 students completed the module and the USMLE Step 1 exam. Of those, 77 (69%) gave informed consent for the study. As previously published, overall attendance at nonmandatory sessions in the module was low, with mean of 18 students (24% of the study group) attending each lecture-based session and 10 (13%) attending each of the nonmandatory small groups (15). Our previous study also demonstrated that there was no correlation between attendance and final examination performance (15). The present study extends this observation, since there was no correlation between attendance at nonmandatory sessions and the USMLE Step 1 score (r = −0.15; P = 0.21).

The Webcourses event log showed that, of the 2,000 min of lecture video, students viewed a mean of 1,212 min (SD 788) [60.6% (SD 39.4)] with the median 1,250 min (range 0–3,647) [62.1% (range 0–182)]. There was a negative correlation of lecture attendance with the viewing of lecture videos (r = −0.502, P < 0.001). The percentage of lecture attendance was combined with the percentage of the lecture videos viewed into a single metric: total lecture consumption. Mean total lecture consumption was 85.0% (SD 35.1) with a median of 92.9% (range 0–210), showing that the majority of students consumed the lectures either in person or through viewing the online videos.

There is no significant correlation between the measurable access of the formal curriculum and the scores on the final examination or USMLE Step 1 (Table 1). A final metric of usage of the formally presented curriculum was assessed by combining the in-person lecture attendance, the lecture video viewing, and the viewing of SLMs: total curriculum consumption. Figure 1 shows that there is no correlation between total curriculum consumption with Step 1 performance (r = −0.086; P = 0.46). The same correlation to the final examination was similarly absent (r = −0.052; P = 0.66).

The usage and performance on the formative and summative assessments was compared with the final examination and Step 1 performance. Figure 2 shows the strong positive correlation, with a large effect size (5), when comparing the final summative examination score with the Step 1 score (r = 0.813; P < 0.001). There were also significant correlations corresponding to moderate effect sizes, between both the mean of the summative IRAT scores and the formative quiz scores and the final examination or Step 1 scores (Table 1). In contrast, the pattern of formative quiz usage did not correlate with examination outcomes. This was evaluated in three ways: quizzes taken, quizzes taken on time and total attempts. “Quizzes taken” refers to the percentage of quizzes taken at any time before the end of the module. “Quizzes taken on time” refers to the percentage of quizzes taken as they were presented throughout the module, from the time they opened at the end of each week until classes resumed the following week. “Total attempts”...
outside resources were se


to the summation of the attempts from all five quizzes (Table 1).

Survey data. Of the 77 students who completed the study, 48 (62\%) completed the online survey. Figure 3 shows the responses to the survey question, “How important are each of the following course resources to your learning.” Students placed high importance on artifacts that they could review on their own time (PowerPoint files, SLMs, case answers, and the video recordings of the lectures), whereas they place lower importance in in-person sessions (live lectures, in person case-based learning, and TBL sessions). The exception to this pattern was the recommended readings. While they were almost universally available online, they were the least valued resource. Figure 4 shows the percentage of students who were using third-party resources that are not specifically recommended in the formal curriculum as a part of their study habits. There were over 15 different third-party resources chosen by the students, with approximately $\geq80\%$ of the students using four resources: Uworld, Pathoma, First Aid, and Sketchy.

Focus group data. Seventeen students participated in a focus group (high attenders: 5; medium attenders: 6; low attenders: 6). There were several themes that were common to all of the focus groups. The major factor on whether to attend lecture was consistent across groups, namely, the quality of the professor and style of teaching (high attenders: “I think it depends on who’s teaching it. At this point in our education, I feel like we’re all pretty familiar with the professors and their desired teaching styles”; low attenders: “Just I guess the professor, for me. If I like them I’ll go, if I don’t [laughter]... Not necessarily their personality, but the way they teach. I might like them in person but not like the way they teach”). The major benefit of attending lecture was as a source of accountability for keeping on schedule. However, the major disadvantage seen was inefficiency compared with online learning.

Although the use of outside resources was universal and extensive, they were seen as supplementary/complementary to the formal curriculum for studying for the module’s exam. Outside resources were seen as efficient and more in line with Step 1 performance. Final examination score is the percent correct out of 118 multiple-choice items. $n = 77$ Students.
which can be kind of frustrating . . . like you're wasting your time"; low attenders: “. . . I've come to hate them because there’s no passion. Everybody just wants to get done with them and go home . . . everyone's just rushing and trying to get as much done as they can so they can go back to their own schedule”).

SLMs were variably used, but students agreed on the characteristics that made a good SLM: quality of user control, lack of cognitive overload (i.e., lower density of material), and inclusion of feedback questions. The formative quizzes were the most popular curriculum resource. Students appreciated the detailed feedback accompanying each question. The quizzes were seen as a signpost for what to study and allowed for progress monitoring.

**DISCUSSION**

Within our ability to detect it, the degree of access of the formal curriculum, either by classroom attendance or by accessing artifacts online, does not correlate with performance in the module or Step 1. The reason behind this is likely multifactorial. For one, the data do suggest that the majority of students are accessing the module’s content. The median usage of lecture, combing both video access and in-person attendance, was 92.9%. With so few students not accessing lecture in one format or another, it is unlikely that we would have been able to detect a difference. The access of module artifacts appeared lower, with a median of 77.6%, although this may be an underestimate because students have mentioned informally that one student sometimes downloaded and organized the week’s slide sets and shared it with several classmates.

Finally and likely most importantly, lack of engagement with the formal curriculum does not necessarily mean that the students are not engaged with the material. The preclinical curriculum is intended to prepare the students for the important task of entering the clinical clerkship arena. However, we cannot escape the fact that it also needs to prepare them for Step 1 for which there are many third-party resources. If a student chooses to use these resources instead of the formal curriculum, it makes sense that they would perform well on any examination intended to test the same knowledge. The module faculty are the authors of the module examination, and the students in the low-attenders’ focus group acknowledge that the formal curriculum materials are useful for determining what the faculty see as testable material. While this suggests that students who have higher participation in the formal curriculum would potentially have an advantage on the internally developed examination over those who did not fully participate, the data in this study do not support that. Furthermore, the high correlation between our final examination and Step 1 suggests we are testing very similar constructs and materials.

Performance on our internal formative and summative assessments predicted performance on Step 1. Multiple studies have shown that previous exam performance can be predictive of Step 1 performance. While this was not the main focus of their study, Cuddy et al. (7) showed that the scores on the Biological Sciences and Physical Sciences sections of the old Medical College Admissions Test positively correlated with Step 1 performance in an evaluation of over 60,000 student across 133 medical schools. Several studies have shown that

Table 2. Matrix of P values for pairwise comparisons for student perception of utility of different learning artifacts

|                  | PPT Lecture Files | Clinical Case Answers | SLMs | Recorded Lectures | In-Person Cases | TBL | In-Person Lecture |
|------------------|-------------------|-----------------------|------|-------------------|-----------------|-----|-------------------|
| Clinical case answers | 1.00              | 1.00                  | 0.13 | 1.00              | 0.001*         | 0.001* | 0.002*           |
| SLMs              | 1.00              | 0.13                  | 1.00 | 1.00              | 0.002*         | 0.002* | 0.136             |
| Recorded lectures | <0.001*           | <0.001*               | <0.001* | 0.002*         | 0.001*         | 0.001* | 0.002*           |
| In-person cases   | <0.001*           | <0.001*               | <0.001* | <0.001*        | 0.03*          | 0.02*  | 1.00              |
| TBL               | <0.001*           | <0.001*               | <0.001* | <0.001*        | 1.00           | 1.00   | 1.00              |
| In-person lecture | <0.001*           | <0.001*               | <0.001* | <0.001*        | 0.002*         | 0.04*  | 0.17              |
| Reading           | <0.001*           | <0.001*               | <0.001* | <0.001*        | <0.001*        | 0.17   | 0.20              |

Comparison was made by Kruskal–Wallis ANOVA followed by pairwise Mann–Whitney U comparisons. P values are adjusted by the Bonferroni correction for multiple tests. PPT, PowerPoint; SLMs, self-learning modules; TBL, team-based learning. *Significant difference.
the NBME Comprehensive Basic Sciences Exam, which is made up of retired Step 1 questions, correlates with Step 1 scores (12, 14). Brenner et al. (2) showed that similar results could be found using the NBME Customized Assessment Service as a formative tool. Finally, Lee and Kibble (17) showed that the internally developed summative exams at UCF all positively correlated with performance on Step 1, with the highest being the GI/Renal Module.

While the score on the formative assessments was a predictor of performance on summative examinations, the pattern of usage was not. The vast majority of the students in the study completed the quizzes at some point before the end of the course (mean 94% and median 100%), whereas a much smaller fraction of students completed them at the time that they were published (mean 43.3% and median 40%); neither parameter had a correlation with outcome on the final examination or Step 1. This is contrary to a previously published study from our institution where they found that the degree to which students voluntarily chose to participate in the weekly formative quizzes as they were published correlated with their exam performance (16). The reason for difference between our institution’s older study and the present data is unclear, although notably the first study was done before the existence of the external quizzing resources described in Fig. 4.

Our data indicate that students are not entirely departing from the formal curriculum, but rather are supplementing it with outside resources. However, they are not consuming it in the faculty’s presence, and many are removing themselves from the social aspects of learning that attendance can provide. The high-attenders focus group speaks to the benefit that these students see in the social aspects of learning, whereas this same sentiment is notably absent from the low-attenders group. The concern this has engendered in our faculty is the possible effect on downstream clinical skills that are vital for patient care: communication, empathy, and critical thinking/clinical reasoning skills. While our data do not speak to this directly, further work is needed to see if these changing patterns of student behavior have wider impacts.

Another concern is possible effects on student well-being. Several studies have shown that the second-year in the medical curriculum has the highest level of student burn-out (10, 18). It is also widely recognized that the focus on Step 1 performance has had many unintended adverse consequences. A recently published article relating the student perspective on the “Step 1 Climate” by Chen et al. (4) with its accompanying faculty commentary by Andolsek (1) speak strongly to the adverse effects on student well-being. Could this loss of the social aspects of the learning environment be worsening this problem in second-year students?

A strength of our present data is that it was prospectively collected objectively describing student behavior, as opposed to retrospective student perception of their behavior. A downside of the data is that there is a limit to what it can tell us about the student’s true study habits. We can state whether a student is attending class or accessing the materials online. However, the data do not enlighten us as to what happens after students harvest material: the student who uses the materials as part of an effective study strategy and the student who does no more than collect it would look the same. Curriculum reform is an area of active discussion at our institution and includes a review of pedagogy to address student engagement with faculty and with each other, and to better integrate online and face-to-face learning sessions and materials.

The generalizability of our study may be limited, since it is based on a single course within a single institution. Any comparisons to Step 1 outcome also have to include the fact that the course materials only cover a fraction of the total content covered in the USMLE content outline. That being said, it seems clear that the pattern of attendance and access of formal curriculum materials cannot reliably help us predict performance on knowledge-based assessments. We need to remember that USMLE Step 1 only assesses one aspect of patient care: medical knowledge. Future studies are needed to determine whether current patterns of student engagement affect the development of medical competencies in other domains. Anecdotally, some faculty are also disheartened by the shift in student engagement patterns, and further work is needed to understand effects on the learning environment that go beyond student mastery of medical knowledge.

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

AUTHOR CONTRIBUTIONS
C.A.K., M.D., A.A., and J.D.K. conceived and designed research; C.A.K., M.D., and J.D.K. analyzed results of experiments; C.A.K. prepared figures; C.A.K. drafted manuscript; C.A.K., M.D., A.A., and J.D.K. Revised and edited manuscript; C.A.K., A.A., and J.D.K. approved final version of manuscript; M.D. performed experiments.

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