Curricular Integration of Physiology

Attitude, but not self-evaluated knowledge, correlates with academic performance in physiology in Thai medical students

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HOW WE TEACH | Curricular Integration of Physiology

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Kwankajonwong N, Ongprakobkul C, Qureshi SP, Watanatada P, Thanprasertsuk S, Bongsebandhu-phubhakdi S. Attitude, but not self-evaluated knowledge, correlates with academic performance in physiology in Thai medical students. Adv Physiol Educ 43: 324–331, 2019; doi:10.1152/advan.00047.2019.—Positive attitude and self-evaluation are necessary for medical students and doctors. To explore how best to integrate physiology teaching in our Thai medical curriculum, we investigated relationships between student’s academic performance, attitude, self-evaluated knowledge, and proportion of physiology taught in an organ-system integrated block. We organized 13 physiology laboratory classes, during which students self-rated attitude and knowledge. Academic performance was measured by formative and summative assessments. One hundred thirty-six participants were categorized into most proactive (Most PA), more proactive (More PA), less proactive (Less PA), and least proactive (Least PA) attitude groups by self-preparation questionnaire. Eighty participants were categorized into high (HighE), moderate (ModerateE), and low (LowE) self-evaluation rating groups. Mean formative score in the Most PA group was significantly higher than in the other PA groups ($P = 0.003$, $P = 0.001$, and $P < 0.001$, respectively). Mean summative score in the Most PA group was significantly higher than the Less PA and the Least PA groups ($P = 0.017$ and $P = 0.015$ respectively). There was no significant difference in mean assessment scores among HighE, ModerateE, and LowE groups. Proportion of teaching time dedicated to physiology positively correlated with student attitude ($r = 0.84$, $P = 0.001$) and negatively correlated with self-evaluation rating ($r = -0.73$, $P = 0.007$). Thai medical students may benefit from a proactive attitude to studying physiology, contrasting with traditional didactic expectations of Thai education. Proportion of teaching time dedicated to physiology does not influence academic performance; therefore, future adjustments to curriculum integration may incorporate classes that facilitate self-directed learning. Future study should explore other influences on learning and assessment performance.

assessment; attitude; curriculum integration of physiology; physiology education; self-evaluation

INTRODUCTION

Success of medical students’ learning and academic performance is largely measured by their performance in assessments. Many previous studies have investigated potential factors influencing academic performance (1, 15, 16). Students’ attitude has been recognized as one such factor in university students (6). Previous studies in medical students have also established that students with more positive attitudes have better academic performance (19, 22). For example, previous authors have indicated a more positive attitude as corresponding to students studying after class (22). However, medical students’ attitude appears to become more negative as they progress through their studies. Although reasons for the change in attitude are not clear, the negative effect of the medical curriculum is involved (22).

As medical knowledge is continuously expanding, self-evaluation of one’s own knowledge limitations and learning needs is considered to be a crucial attribute for life-long professional learning among medical doctors (9). However, the ability to self-evaluate is not easily acquired. Previous studies of medical students have found low predictability of self-evaluation of academic performance (18). The students’ estimates of their performance were not accurate compared with their actual performance. Many factors, such as sex, anxiety, and integrated block curricula, are found to be associated with the accuracy of self-evaluation (3–5, 11).

Contemporary universities adopt medical curricula that are systems based, with integrated teaching blocks for organ systems. These differ from traditional discipline-based curricula and are designed to facilitate students in relating knowledge of physiology, anatomy, biochemistry, and other disciplines to solve problems related to each organ system (21). The integrated curriculum is intended to reduce the sense of fragmentation and information overload of individual disciplines (7, 10). Students receiving integrated teaching may perform better academically than those receiving traditional teaching (7, 12, 14). Conversely, one challenge presented by integrated curricula is discerning how much time should be allocated for physiology, since physiology may appear complicated for students in their early years of medical education. Students misunderstanding the scope of what they should learn are at risk of superficial learning. It has been speculated that students may form negative attitudes toward learning physiology principles, as their importance may be underestimated in integrated curricula (11).

In our setting of a Thai medical school with an integrated medical curriculum, we are seeking to maximize physiology learning. It is, therefore, essential to consider the factors that influence academic performance of our medical students in...
physiology to inform how we integrate and deliver physiology teaching in our curriculum and in our cultural context.

Study aims. This study continues to build on a body of research in which we investigate how medical students in our Southeast Asian context learn and perform in physiology and how best to integrate and deliver physiology teaching into the undergraduate medical curricula in Thailand (23). Medical education in Thailand tends to rely on more didactic, teacher-led teaching and learning activities compared with self-directed and student-centered learning, which would be expected in Western contexts. As much existing medical education literature is based in Western cultural contexts, we seek to produce a body of evidence that contributes to curriculum integration and teaching of physiology that is relevant in the context of Thai and other Southeast Asian medical students.

This study aimed to investigate the factors that influence academic performance in physiology for Thai medical students. Based on background literature, we identified proactive student attitude and student self-evaluated knowledge as useful factors to study, and we wished to know how these may affect our student population. The specific aims we sought to address were as follows. The first is to investigate the relationship between students’ attitude and academic performance. The second is to investigate the relationship between students’ self-evaluated knowledge and academic performance. The third is to investigate any relationship between students’ attitude and self-evaluated knowledge. The fourth is to investigate whether the proportion of teaching time dedicated to physiology in the integrated medical curriculum influences students’ attitude, students’ self-evaluated knowledge, and student’s academic performance.

We hypothesized that academic performance would be positively associated with both positive students’ attitude and with students’ self-evaluated knowledge. We also hypothesized that students’ attitude would be positively associated with self-evaluated knowledge. In addition, we hypothesized that the proportion of teaching time would be positively associated with students’ attitude, self-evaluated knowledge, and academic performance.

METHODS

Ethical considerations. The study was granted research ethics approval by the Institutional Review Board of the Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand. All students participated voluntarily. In the process of recruitment, students were informed that declining to participate would not affect their grades. Informed consent was obtained in writing from all participants.

Study population. Medical training in Thailand requires completion of a 6-yr undergraduate medical degree before being qualified to begin practice as a Doctor of Medicine (MD). Thai undergraduate medical curricula are typically divided into a 3-yr preclinical phase and 3-yr clinical phase. This study was carried out in medical students during their second (preclinical) year from June 2016 to February 2017, in the Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand. In total, 298 students in the class were invited to participate in the study. The current second-year curriculum was organized into organ system integrated blocks resulting from the collaboration of instructors from numerous departments. Therefore, physiology laboratory classes (LCs) were distributed throughout the year according to the correlating blocks.

Interventions. Throughout the second year of the medical degree program, we organized 13 physiology LC sessions, the details of which are presented in Table 1. All students were advised to read the laboratory directions for preparation a few days before each LC. Whether individual students reviewed materials in the advance of LCs was used as a proxy marker of their attitude, i.e., whether proactive or not. During each LC session, the instructors introduced the student to relevant physiological material and provided instruction. Then the students engaged in practicing examination skills or interpreting and discussing laboratory data. Before the end of each LC, the instructors summarized essential content, and the students undertook a formative assessment.

At the end of the formative assessments, the participants were asked whether they had prepared for the LCs in advance, for example, “Did you read the laboratory directions before this LC?” The answers were used to categorize participants based on “attitude rating.” Affirmative answers were counted as positive responses.

Participants were also asked if they satisfactorily understood content of the LC, for example, “Do you understand gastrointestinal secretion more thoroughly after this LC?” The answers were used to categorize them based on “self-evaluation rating.” Responses indicating understanding were counted as positive responses. The percentage of the participants who had positive and negative responses to these questions in each individual LC was calculated.

For an overall view of attitude throughout the second year of the medical degree, we categorized students by 13 attitude questions from all 13 LCs. Students who had positive responses to the attitude question more than five times, four to five times, two to three times, and zero to one time were assigned as most proactive attitude (Most PA), more proactive attitude (More PA), less proactive attitude (Less PA), and least proactive attitude (Least PA) groups, respectively. Separately, students were categorized by 13 self-evaluation questions from all 13 LCs. Participants who had positive responses to the self-evaluation question >10 times, 9–10 times, and <9 times were assigned as high (HighE), moderate (ModerateE), and low self-evaluation rating groups (LowE), respectively.

Although physiology LCs occur as part of organ system integrated blocks, the weight of, or focus on, the physiology teaching does not equally distribute across each block. Thus we defined “proportion of physiology” as proportion of the physiology teaching time to total teaching time in that individual block, to determine how much physiology contributes to the teaching of that organ system in our degree. For example, LC-8: Physiology of Gastrointestinal Secretion, was in the gastrointestinal system block. The total time of every lecture, laboratory, and case discussion in the block was 50 h. Because there was 18 h contributed to physiology out of 50 h, we calculated proportion of physiology for LC-8 by 18 h divided by 50 h, which equates to 36%.

Outcome measurement. The outcome measurements were obtained as formative and summative assessment scores. The formative physiology assessments were conducted ~15 min after each LC. The assessments consisted mostly of multiple-choice questions, with some true/false questions, and examined basic and clinical physiological knowledge. This score was intended for early assessment of learning outcomes and did not contribute to summative grades. After the end of each block, the students undertook the integrated summative assessment. Summative assessments were integrated and consisted of multiple-choice questions covering all disciplines in the blocks, e.g., physiology, anatomy, biochemistry, etc. The summative scores were used to assess learning corresponding to long-term learning outcomes. The formative assessment was used for early assessment of the learning outcomes, whereas the summative assessment was used to evaluate long-term learning. Both formative and summative assessments were carefully designed to align with the curricular learning outcomes and the teaching and learning activities carried out in LCs, correlating with the concept of constructive alignment (2).

Statistical analysis. Demographic data were analyzed descriptively and were recorded for every participant who completed any
number of questionnaires. Repeated-measures analysis of variance (ANOVA) was used to analyze the difference of total formative and summative scores among different student groups categorized by overall attitude and self-evaluating questions from all LCs. Fisher’s least significant difference was used as post hoc analysis to explore differences between pairs of mean scores of different student groups. Only participants who completed all questionnaires for attitude and for self-evaluation were included in the respective final analysis for each category. Additionally, students’ attitude and self-evaluation rating were analyzed for possible relationships to the proportion of physiology. This analysis was done by using bivariate correlation (Pearson’s correlation coefficient, r). The accepted level of significance was set at $P < 0.05$. The averaged formative and summative scores are presented as means ± SD. Statistical analyses were performed using IBM SPSS Statistics version 23.

Table 1. Contents of each laboratory class and its details

| LC | Contents of LCs                                                                 | Format of LCs                      | Organ System Block of LC in the Medical Course                  | Physiology Proportion of Total Teaching Time, % |
|----|---------------------------------------------------------------------------------|------------------------------------|-----------------------------------------------------------------|-------------------------------------------------|
| LC-1: Autonomic Nervous System Integration | ● Demonstration of effects of autonomic nervous system drugs in dog | Interpreting laboratory data       | Fundamentals of Tissue Biology and Human Function               | 29.31                                           |
| LC-2: Physiology of Nerve and Neuromuscular Junction | ● Demonstration of effects of neuromuscular-blocking drugs on muscle contraction in frog | Interpreting laboratory data       | Musculoskeletal System                                           | 8.24                                            |
| LC-3: Physiology of Skeletal Muscle | ● Demonstration of contraction periods and summation of contraction of muscle in frog | Interpreting laboratory data       | Musculoskeletal System                                           | 8.24                                            |
| LC-4: Physiology of Reflex | ● Examination of superficial reflexes, deep tendon reflexes, and autonomic nervous system reflexes | Practicing examination skills       | Musculoskeletal System                                           | 8.24                                            |
| LC-5: Chest Movement and Breath Sound | ● Physical examination of respiratory system | Practicing examination skills       | Respiratory System                                               | 44.19                                           |
| LC-6: Pulmonary Function Test | ● Measurement of forced vital capacity and forced expiratory volume in 1 s by spirometer | Practicing examination skills       | Respiratory System                                               | 44.19                                           |
| LC-7: Cardiovascular System Integration | ● Demonstration of cardiovascular diseases and drugs on arterial pressure and heart rate in dog | Interpreting laboratory data       | Cardiovascular System                                            | 72.14                                           |
| LC-8: Physiology of Gastrointestinal Secretion | ● Demonstration of salivary, bile, and pancreatic secretions in dog | Interpreting laboratory data       | Gastrointestinal System                                          | 36.00                                           |
| LC-9: Renal Function | ● Demonstration of effects of hemorrhage, drugs, and some substances on renal function in dog | Interpreting laboratory data       | Urinary System                                                   | 45.61                                           |
| LC-10: Reproductive Physiology | ● Demonstration of effects of male and female sex hormones on estrous cycle, secondary sex organs, body weight, and activity of rats | Interpreting laboratory data       | Reproductive System                                              | 55.17                                           |
| LC-11: Physiology of Sensation | ● Examination of skin sensation, olfactory sensation of various odors, and taste sensation of various substances | Practicing examination skills       | Neuroscience                                                     | 30.49                                           |
| LC-12: Physiology of Vision | ● Accommodation and light reflex examination  
● Visual acuity, visual field, and color vision test  
● Retinal examination with ophthalmoscope | Practicing examination skills       | Neuroscience                                                     | 30.49                                           |
| LC-13: Physiology of Auditory and Vestibular System | ● Ear examination with otoscope  
● Audiometric testing and interpretation  
● We&rsquo;s and Rinne&rsquo;s test  
● Nystagmus (triggered by rotating chair) | Practicing examination skills       | Neuroscience                                                     | 30.49                                           |

LC: laboratory class.
RESULTS

Participant characteristics. Of the recruited 298 participants, 161 (54.0%) were men and 137 (46.0%) were women. Because some students did not respond to attitude questions or self-evaluation questions in some LCs, there were only 136 participants (45.6%) who completed all attitude questions. Categorizing by attitude questions, 10 participants (7.4%) were classified in the Most PA group, 22 (16.2%) in the More PA group, 62 (45.6%) in the Less PA group, and 42 (30.9%) in the Least PA group. There were 80 participants (26.8%) who completed all of the self-evaluation questions. Categorizing by the self-evaluation questions, 50 participants (62.5%) were classified in the HighE group, 22 (27.5%) in the ModerateE, and 8 (10%) in the LowE group.

Relationship between assessment scores and attitude. The total number of participants included in this analysis was 136. The mean scores of the formative assessments from all sessions were 80.76 ± 6.72 in Most PA, 73.40 ± 5.94 in More PA, 73.66 ± 6.52 in Less PA, and 72.70 ± 6.26 in Least PA, with a significant difference between the groups (P < 0.005). Post hoc analysis revealed that the mean formative score of the Most PA group was significantly higher than those of the More PA group, Less PA group, and Least PA group (P = 0.003, P = 0.001, and P < 0.001, respectively), whereas there was no significant difference between More PA, Less PA, and Least PA groups (P > 0.05) (Fig. 1A).

The mean scores of the summative assessments from all blocks were 79.90 ± 5.95 in the Most PA, 75.86 ± 6.52 in the More PA, 72.80 ± 8.97 in the Less PA, and 72.41 ± 9.55 in the Least PA group, with a significant difference between the groups (P = 0.048). Post hoc analysis revealed that the mean summative score of the Most PA group was significantly higher than those of the Less PA and Least PA groups (P = 0.017 and 0.015, respectively), but not from that of the More PA group (P = 0.222). There was no significant difference between the More PA, Less PA, and Least PA groups (P > 0.05) (Fig. 1B).

Relationship between assessment scores and self-evaluation. The total number of participants included in this analysis was 80. The mean scores of the formative assessments from all sessions were 80.76 ± 6.72 in Most PA, 73.40 ± 5.94 in More PA, 73.66 ± 6.52 in Less PA, and 72.70 ± 6.26 in Least PA, with a significant difference between the groups (P < 0.005). Post hoc analysis revealed that the mean formative score of the Most PA group was significantly higher than those of the More PA group, Less PA group, and Least PA group (P = 0.003, P = 0.001, and P < 0.001, respectively), whereas there was no significant difference between More PA, Less PA, and Least PA groups (P > 0.05) (Fig. 1A).

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Relationships between proportion of physiology and summative scores. The mean formative and summative scores of all students were calculated for each LC. No significant linear relation was found between the proportion of physiology and the mean formative score (r = −0.48, P = 0.159) (Fig. 3C).

Relationships between proportion of physiology and assessment scores. The mean formative and summative scores of all students were calculated for each LC. No significant linear relation was found between the proportion of physiology and the mean formative score (r = −0.30, P = 0.324) (Fig. 4A). The proportion of physiology also did not have significant linear correlation with the mean summative score (r = −0.39, P = 0.189) (Fig. 4B).

DISCUSSION

Our analyses have led to findings with implications for the delivery of physiology teaching and assessment in Thai medical education. First, we found a proactive attitude to preparation before LCs to be associated with significantly higher academic performance in both formative and summative assessments. Preparation by reviewing materials in advance of class time may help students more effectively study physiology compared with those who attend class without preparation in

Fig. 1. Box and whisker plots (2.5–97.5th percentile) showing distribution of formative score (A) and summative score (B) of the students in the most proactive (Most PA; n = 10), more proactive (More PA; n = 22), less proactive (Less PA; n = 62), and least proactive (Least PA; n = 42) groups. The plus symbols indicate the mean scores of each group. *Significantly different (P < 0.05).
may represent a potential reduced benefit of proactive attitude when physiology is examined in an integrated way. This raises concerns for integrated medical degrees, and potentially for clinical practice: when these students begin practice as doctors, they will need to access knowledge across scientific disciplines to solve real-world clinical problems in integrated ways.

Interestingly, we also found there was no relationship between overall self-evaluated knowledge and academic performance. For students within the HighE category (the highest advance and, consequently, perform better in assessments. This is noteworthy in our Thai context, where self-directed learning is less common compared with Western education. It indicates the importance of setting clear expectations for students and allows us to present evidence to our medical students that a more proactive attitude is correlated with improved assessment performance. Therefore, it is in their best interests to prepare for classes in advance.

Another key finding was that the association between attitude and formative scores was more apparent than between attitude and summative scores. One possible explanation is that a proactive attitude is short-lived and does not necessarily affect preparation for summative assessments. It is perhaps concerning that preparation a few days before LC may raise the score of the upcoming formative assessment more than the summative assessment and raises questions about what other influences may affect performance in summative assessments. This may represent a disparity between deep and superficial learning, which has been raised as a concern for integrated curricula such as ours (11). Another potential explanation is a difference in student performance between physiology-only assessments (such as in the formative assessments) and integrated assessments (such as our summative assessments). This

Fig. 2. Box and whisker plots (2.5–97.5th percentile) showing distribution of formative score (A) and summative score (B) of the students in the high self-evaluation (HighE; n = 50), moderate self-evaluation (ModerateE; n = 22), and low self-evaluation (LowE; n = 8) groups. The plus symbols indicate the mean scores of each group. No significant difference between the three groups was found.

Fig. 3. Interrelationships among proportion of physiology, student’s attitude, and self-evaluation rating. A strong correlation between proportion of physiology vs. students’ attitude (r = 0.84, P = 0.001; A) and self-evaluation rating (r = −0.73, P = 0.007; B) was found. C: students’ attitude has little association with self-evaluation rating (r = −0.48, P = 0.159).
self-evaluated knowledge), there was a wide variation in performance on assessments. This finding was in accordance with previous findings that low-performing students tend to overestimate their academic grades (8). Low-performing students may be unable to recognize their lack of knowledge, leading to a false sense of satisfaction in one’s own knowledge. Consequently, they may not be motivated to study sufficiently, compared with students who perceive their knowledge as inadequate.

The results also demonstrated that there were more students who had a positive attitude in the LCs with a higher proportion of physiology. Nonetheless, there were fewer students who gave positive responses to the self-evaluation question in the LCs with a high proportion of physiology. We can extrapolate from the findings that the greater proportion of physiology may help students gain a better recognition of their knowledge level, resulting in a reduction in self-evaluation of knowledge. Consequently, this may motivate students to study more in advance of class and lead to a more proactive attitude. An alternative view of this potential phenomenon could be explained using the Johari Window (20). Through this model, students who become aware of their own learning needs could be seen as moving from “unknown unknowns” to “known unknowns.”

It is noteworthy that our findings indicate that the proportion of physiology is negatively correlated with student self-evaluated knowledge and is not directly related to higher academic performance. This raises questions of the utility of classroom time in physiology and possible alternative uses of face-to-face teaching. In some western settings, a flipped classroom format has been adopted. This involves students taking more responsibility for their own learning and studying material in their own time, while using face-to-face teaching to apply knowledge to worked examples, clear up misconceptions, and consolidate their learning from self-study (1). Although this educational approach relies on student self-directed learning, which is not usual for our cultural context, our findings imply that this approach could be effective if implemented. Conversely, the proportion of time spent on physiology teaching correlates positively with students being more proactive, and so there is a counterargument that the current format should be maintained. Therefore, the proportion of physiology may not have direct effects on academic performance, as measured by scores in both formative and summative assessments. However, the proportion of physiology may have indirect effects on academic performance through effects on students’ attitude.

This study benefited from its simple, replicable design. Through this relatively simple study, we were able to follow up medical students at one university for the period of one year and derive significant insights into influences on their performance in physiology. We consider our outcomes to have been measured with valid tools, i.e., assessments that were developed by subject experts to ensure alignment with learning outcomes and teaching and learning activities. This study has made a significant contribution to existing literature by being the first to demonstrate the importance of student proactive attitude and appropriate allocation of physiology in an integrated medical curriculum in a Thai learning environment. It has led to new implications for our context related to more self-directed learning and alternative teaching approaches, such as the flipped classroom. This challenges preexisting assumptions about expectations of students and teachers in Thailand and causes us to reevaluate how we integrate physiology into our curriculum. Furthermore, our research explored the effect of proportions of physiology in organ-system integrated blocks, providing novel findings related to curriculum integration, which allows us to argue for self-directed learning in physiology among preclinical medical students in Thailand.

Limitations of our study included the small scale and the fact that the findings have not yet been replicated. Randomization was precluded due to the structure of the medical degree and because all students needed to be exposed to the same teaching. Unfortunately, there was attrition of recruited participants over the year: although all students invited to participate completed the questionnaires, we were only able to include data for those who completed the questionnaires for every LC in the respective analyses. Another potential criticism was utilizing participants’ self-reporting to categorize them according to both attitude question and self-evaluation. Furthermore, for simplicity, categorization was done in a binary way, which may not capture all pertinent information. For example, participants were asked if they prepared in advance of class, but those who answered “yes” may include a binary way, which may not capture all pertinent information. For example, participants were asked if they prepared in advance of class, but those who answered “yes” may include a spectrum of those who had only briefly reviewed, compared with others who may have spent hours studying intently. Moreover, many other factors may account for student behavior and performance in assessments other than those measured in this study. We have considered these limitations of the...
Further study. Further study should aim to answer research questions emerging from our study: medical student proactive attitude is correlated with academic performance, yet other factors may influence behavior, learning, and academic performance. It is not clear why students have different attitudes and have different perceptions of their own physiology knowledge. Furthermore, the mechanism by which the proportion of physiology may influence academic performance and self-evaluated knowledge is unclear. The reason why a proactive attitude appears to influence formative assessment performance more than summative assessments has been speculated, but it is not certain. So far, students’ attitude and self-evaluated knowledge were gathered via a binary, quantitative measurement. There are other ways in which students’ attitude and factors affecting student learning and behavior may be investigated. In further study, to investigate the above outstanding questions, qualitative research should be considered, which is more useful for investigating attitudes, perceptions, and behaviors, as opposed to quantitative measurements (13). Ultimately, further study should investigate possible interventions to promote academic performance, students’ attitude, along with accuracy of self-evaluation rating, potentially incorporating a flipped classroom approach and assessing the impact in our Thai context. In addition, preclinical performance of physiological knowledge in assessment is not the same as application in clinical practice. Thus future research should investigate relationships between preclinical physiology teaching, learning, and assessment, and clinical practice.

Conclusion. Proactive attitude toward physiology, demonstrated by studying in advance of LCs, was associated with higher academic performance in physiology among Thai medical students. The effect was weaker in integrated summative assessments compared with formative physiology-only assessments, raising questions of how deep, lasting learning can be encouraged, and how students prioritize studying physiology alongside other subjects in studying for integrated assessments. Negotiating disciplines in an integrated way is essential for eventual clinical practice as doctors, which will involve integrated management of patients. In contrast, self-evaluated knowledge did not predict academic performance, with a tendency for overestimation in students with low academic performance. Furthermore, a higher proportion of physiology teaching within integrated organ system blocks in the curriculum was positively correlated with students’ attitude toward studying physiology, yet it negatively correlates with student’s self-evaluated knowledge in physiology. There was no correlation between proportion of time spent in physiology class and performance in formative or summative assessments. Possible implications of the findings include that the traditional, didactic-based approach to teaching physiology in Thai medical education may be suboptimal, and this challenges us to consider whether more self-directed learning and alternative uses of classroom time may provide a better approach to learning physiology in an integrated curriculum. Active learning methods, such as interactive LC, have already been introduced as a new, nontraditional method for teaching in our context (23), but the findings of the present study suggest that an overall review of the integrated curriculum may be considered. However, further research is needed to explore students’ learning behavior and how their beliefs and attitudes influence their performance in assessments.

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DISCLOSURES

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

AUTHOR CONTRIBUTIONS

N.K., C.O., S.P.Q., P.W., S.T., and S.B.-P. conceived and designed research; N.K., P.W., and S.B.-P. performed experiments; N.K. and S.T. analyzed data; N.K., S.P.Q., and S.B.-P. interpreted results of experiments; N.K. and S.B.-P. prepared figures; N.K., C.O., and S.P.Q. drafted manuscript; N.K., C.O., S.P.Q., S.T., and S.B.-P. edited and revised manuscript; N.K., C.O., S.P.Q., P.W., S.T., and S.B.-P. approved final version of manuscript.

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