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# Enhancing Learning in Medical Biochemistry by Teaching Based on VARK Learning Style for Medical Students

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**Purpose:** Learners, including medical students, naturally have different learning style preferences. Teachers need to use a variety of teaching materials to help learners understand the content. However, previous studies have not reported the effects of learning in medical biochemistry by teaching based on the VARK learning style. This study aims to investigate the learning style preferences, the effects of learning in medical biochemistry by teaching based on the VARK learning style, and the relationship between type and number of VARK learning styles and medical biochemistry achievement in medical students.

**Methods:** We investigated a total of 92 first-year medical students at Walailak University. The VARK questionnaire was used to identify the learning style preference of medical students. All students took a pretest before beginning each online lecture. After completing each lecture, all students received additional teaching materials according to their learning style to use in reviewing the lessons. All students took a posttest for each lecture after reviewing the lesson.

**Results:** The results showed that the medical students preferred a multimodal learning style (70.65%) more than a unimodal learning style (29.35%). The medical students preferred four learning styles (VARK) more than two and three learning styles. All learning styles had a mean difference score (posttest score minus pretest score) above 27.00 (33.75%). There were no significant differences in mean difference scores among the different learning styles. In addition, there were no significant differences in mean differences, two style preferences, three style preferences, and four style preferences.

**Conclusion:** Teaching based on the VARK learning style could enhance medical students' learning in medical biochemistry. The difference in learning style and the difference in the number of learning styles (single, two, three, and four style preferences) were not significantly related to medical students' learning achievement in medical biochemistry.

Keywords: academic achievement, learning styles, medical education, VARK model

# Introduction

Teaching and learning processes have many components that will make learners successful in their education. Teaching methods are one of the important factors that make learners successful in learning. Teachers should be able to vary their teaching styles to meet the learning styles of individual students.<sup>1</sup> The learning styles of learners can be measured by various models, such as the Kolb experiential learning model, Gregorc learning style model, Felder and Silverman learning style model, Dunn and Dunn model, and VARK model.<sup>2</sup> The VARK model developed by Neil Fleming is the most widely used for categorizing learning styles.<sup>3</sup> VARK is in the category of instructional preference that focus on how learners obtain information. Fleming<sup>3</sup> classified learning styles according to preference for receiving and giving information into 4 perceptual modes: visual (V), aural (A), read/write (R), and kinesthetic (K). However, each learner may prefer more than one perceptual mode, which can be divided according to the number of perceptual mode preferences into 4 types: single style preference (unimodal learning style), two style preferences (multimodal learning styles), three style preferences (multimodal learning styles), and four style preferences (multimodal learning styles).<sup>3</sup> The

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learning style of each learner will vary depending on many factors, such as academic programs and year levels of learner.<sup>4</sup>

Learning styles are different ways in which each individual learns best. Some studies found that learners learn better when they get information that matches their preferred learning style, and learners who know their learning styles can be helpful in determining how and when they learn.<sup>5,6</sup> For example, when learning about the oxygen-carrying capacity of blood through a hands-on kinesthetic activity, 76 physiology students who prefer kinesthetic learning performed better than 73 nonkinesthetic learners who engaged in traditional learning and adapting teaching strategies to each student's preferred visualauditory-kinesthetic (VAK) learning style (n = 106) could enhance their comprehension, performance, and retrieval when teaching respiratory physiology.<sup>7,8</sup> In addition, the VARK questionnaire is currently being used to investigate patients' preferred learning styles (n = 116) prior to heart failure education.<sup>9</sup> A review of the literature shows that the VARK model has been used in teaching and learning in many academic disciplines, such as the VARK model was used for measuring student preferred modes of intaking, processing, and outputting information in an introductory economics course at Australian Catholic University,<sup>10</sup> applied in the data structures and algorithms course for computer science student at Goce Delchev University,<sup>11</sup> and used in pre-clinical chiropractic student to determine the relationship between preferred learning styles and the prevalence of mobile gross anatomy software application usage.<sup>12</sup> The VARK model can be used in a variety of teaching environments, such as in the classroom, online, and in clinical environments.<sup>13</sup> In addition, the VARK model can be used in a variety of teaching methods, such as lecture and problem-based learning (PBL).<sup>14</sup> Understanding the learning style preferences of learners is beneficial for both teachers and students to improve student learning.

The first-year medical students at Walailak University are those who have completed high school and have never graduated from any pre-med degree programs before being admitted to medical school. The medical biochemistry course is a mandatory subject for first-year medical students at Walailak University. The teaching methods in the medical biochemistry course for medical students at Walailak University are a combination of lecture and active learning, including laboratory learning, flipped classroom, and topic assignment. Learning takes place in a classroom normally. However, during the COVID pandemic, learning takes place online.

Currently, online teaching method is increasingly used in many schools. However, it is also lecture-based learning. For medical biochemistry subjects, it is difficult to understand if a teacher teaches students by lecture alone. Therefore, it is necessary to use teaching materials to help learners understand the mechanisms in biochemistry. There are many strategies that teachers can implement in their classes to help their students understand the lesson. One of these strategies is teaching based on the learning style preferences of learners.<sup>15</sup> Many studies have found that academic achievement is related to learning style based on the VARK model,<sup>7,16</sup> while some studies have not reported a significant relationship.<sup>17,18</sup> However, previous studies have not reported the effects of learning in medical biochemistry by teaching based on the VARK learning style. Therefore, the present study aims to investigate the learning style preferences of medical students at Walailak University, investigate the effects of learning in medical biochemistry by teaching based on the VARK learning style, and determine the relationship between the type and number of VARK learning styles and medical biochemistry achievement in medical students.

## **Materials and Methods**

#### Setting and Participants

An experimental study was performed in 2021–2022. This study recruited a purposive sample comprising first-year medical students who had never registered for a course in medical biochemistry at Walailak University. Exclusion criteria included being unwilling to participate in the study and being unable to attend class during the specified period. A total of 92 out of 96 medical students participated in this study, resulting in a response rate of 95.83%.

#### Measurement Instruments

#### Questionnaires

Two questionnaires were used in this study. The first questionnaire was used for learning style determination. Each participant was identified for learning style following the VARK model by using the VARK questionnaire (version 8.01).

The VARK questionnaire consists of 16 multiple-choice items. Each item is associated with a specific style. The respondents could choose more than one choice according to their preferences, and they could leave any unrelated questions blank. Participants have 1 hour to complete the VARK questionnaire in class. There is a reminder 15 minutes before the deadline to complete the questionnaire. The total score in each learning style (visual (V), aural (A), read/write (R), kinesthetic (K)) ranges from 0 to 16. A higher score in each learning style indicates a respondent's preference for that type of learning. If respondents obtain the same score in two or more learning styles, their learning styles are considered multimodal (two style preferences, three style preferences, and four style preferences). The students were divided into fifteen categories based on the following learning styles: V, A, R, K, VA, VR, VK, AR, AK, RK, VAR, VAK, VRK, ARK, and VARK.<sup>3</sup> The second questionnaire comprised general demographic information questions including name, gender, age, the accumulated grade point average (GPAX) out of 4.00 of the two latter semesters, their preference for teaching methods, and the learning style obtained from the VARK questionnaire.

#### **Teaching Methods**

All students attended a total of 4 online lectures on medical biochemistry via the Zoom meeting software by using static PowerPoint as teaching material, covering 1 topic per day for two hours each. Each lecture presented its contents as a static PowerPoint, adhering to the standard curriculum for a first-year medical biochemistry course. All students took a pretest before starting each online lecture. After completing each lecture, all students received additional teaching materials according to their learning style to use in reviewing lessons. Additional teaching materials were animations for visual learning style, audio clips of lecture for aural learning style, handouts and textbooks for read/write learning style, and exercises and group discussion for kinesthetic learning styles. Students who had a multimodal learning style received additional teaching materials according the lesson. The pretest and posttest of each lecture are composed of 20 multiple choice items with 4 choices per item. Each item has 1 point. The total scores of the students out of 80 were obtained from four summative assessment tests.

## Data Collection

Data were gathered between 2021 and 2022 from first-year medical students who had never registered for a course in medical biochemistry at Walailak University. The 4 online lectures on medical biochemistry in this study were a bespoke lecture series administered for the purpose of this research. However, the contents of the four online lectures in this study are consistent with the standard curriculum for a first-year medical biochemistry course. The participation of medical students in this study was completely voluntary, and the results of this study did not affect their grades in the medical biochemistry subjects. Participants were given questionnaires and attended lectures via the Zoom meeting software by using PowerPoint as teaching material after their written informed consent.

## Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics, version 26 (Armonk, NY: IBM Corp). The data were analyzed using descriptive and inferential statistics. Continuous variables were described using the mean and standard deviation. The Shapiro–Wilk test was used to check the normality of the data. The Kruskal–Wallis test with post hoc analysis was used to evaluate the statistically significant differences between the groups of each learning style. The differences between the unimodal and multimodal learning styles were analyzed using one-way ANOVA with post hoc tests using least significant difference (LSD). The significance level was considered less than 0.05.

## **Ethical Considerations**

The ethics committee of Walailak University approved the study with the code WUEC-21-053-01.

## Results

## **Student Demographics**

A total of 92 out of 96 medical students participated in this study: 36.96% (n = 34) were male and 63.04% (n = 58) were female. Age was in the range of 18–21 years. Their mean GPAX was  $3.97\pm0.07$  (out of 4.00).

## Students' Learning Styles

The students' learning styles obtained from 92 medical students who responded to the VARK questionnaire are shown in Table 1. The results showed that the students preferred a multimodal learning style (70.65%) more than a unimodal learning style (29.35%) (Table 1). The multimodal learning style was classified as two style preferences (26.09%), three style preferences (16.30%), and four style preferences (28.26%). These results indicated that the students preferred four learning styles (VARK) more than two and three learning styles. Among the unimodal learning styles, the highest learning style preference was observed for kinesthetic. The learning style preferences of medical students could be arranged in the following order: VARK > K > AK > VK=VAK > A=RK=VRK > V=R=ARK. The learning styles of VA, VR, AR, and VAR were not preferred for medical students (Table 1). These results indicated that kinesthetic learning style was preferred by medical students more than visual, aural, and read/write for both unimodal and multimodal learning styles.

## The Score of Pretest and Posttest

The results of the pretest and posttest scores of medical biochemistry subjects obtained from 92 medical students are shown in Table 2. The highest pretest mean score in medical biochemistry was for the ARK learning style ( $46.00 \pm 2.83$ , 57.50%, ie 46.00/80.00), while the read/write learning style mean score was the lowest ( $35.50 \pm 0.71$ , 44.38%) (Table 2). All learning styles had a mean posttest score above 69.00 (86.25%). The ARK learning style had the highest posttest mean score ( $76.50 \pm 2.12$ , 95.63%), and the visual learning style had the lowest posttest mean score ( $70.00 \pm 1.41$ , 87.50%). However, there were no significant mean differences in pre-/post-test scores among the different learning styles had a mean difference score above 27.00 (33.75%). The read/write learning style had the highest ( $39.50 \pm 0.71$ , 49.38%), and the VRK learning style had the lowest mean differences in pre-/post-test scores among the different mean differences in pre-/post-test scores among the significant mean differences in pre-/post-test scores among the highest ( $39.50 \pm 0.71$ , 49.38%), and the VRK learning style had the lowest mean differences in pre-/post-test scores among the significant mean differences in pre-/post-test scores among the different learning style had the lowest mean differences in pre-/post-test scores among the different learning style had the highest ( $39.50 \pm 0.71$ , 49.38%), and the VRK learning style had the lowest mean differences in pre-/post-test scores among the different learning styles. Moreover, there were no significant mean differences in pre-/post-test scores between the single style preference, two style preferences, three style preferences, and four style preferences (Table 3).

Learning Style	Number	Percent	
Unimodal Single style preference	V	2	2.17%
	Α	3	3.26%
	R	2	2.17%
	К	20	21.74%
	Total	27	29.35%
Multimodal Two style preferences	VA	0	0%
	VR	0	0%
	VK	10	10.87%
	AR	0	0%
	AK	11	11.96%
	RK	3	3.26%
	Total	24	26.09%
Multimodal Three style preferences	VAR	0	0%
	VAK	10	10.87%
	VRK	3	3.26%
	ARK	2	2.17%
	Total	15	16.30%
Multimodal Four style preferences	VARK	26	28.26%

 Table I Learning Style Preferences of First-Year Medical Students

 at Walailak University in 2021–2022 (n=92)

Notes: Subtotal of unimodal single style preference does not add to 29.35% due to rounding.

Abbrevation: V, visual; A, aural; R, read/write; K, kinesthetic.

Learning Style		Pretest	Posttest	Mean Difference
		Mean ± SD	Mean ± SD	Mean ± SD
Single style preference	V	42.00 ± 14.14	70.00 ± 1.41	28.00 ± 12.73
	Α	40.67 ± 6.51	71.00 ± 1.73	30.33 ± 8.08
	R	35.50 ± 0.71	75.00 ± 0.00	39.50 ± 0.71
	К	41.45 ± 6.79	74.40 ± 4.26	32.95 ± 6.55
Two style preferences	VK	37.00 ± 7.97	72.60 ± 4.25	35.60 ± 5.17
	AK	37.09 ± 7.35	71.36 ± 3.85	34.27 ± 5.50
	RK	42.33 ± 1.15	73.00 ± 3.00	30.67 ± 2.08
Three style preferences	VAK	41.50 ± 6.85	75.00 ± 1.63	33.50 ± 6.87
	VRK	45.67 ± 7.51	73.33 ± 5.51	27.66 ± 4.16
	ARK	46.00 ± 2.83	76.50 ± 2.12	30.50 ± 4.95
Four style preferences	VARK	39.31 ± 6.93	74.31 ± 2.83	35.00 ± 6.68

**Table 2** Pretest and Posttest Scores of the Medical Biochemistry Course of First-Year Medical Students at Walailak University in 2021–2022 (n=92)

**Notes:** A full score of 80 both pretest and posttest. The *p*-value for the mean differences scores between the various learning styles was p > 0.05. The learning styles of VA, VR, AR, and VAR were not preferred for medical students.

Abbrevation: V, visual; A, aural; R, read/write; K, kinesthetic.

Table 3 Mean Difference of Pretest and Posttest Scores of Unimodaland Multimodal Learning Styles of First-Year Medical Students atWalailak University in 2021–2022 (n=92)

Learning Style	Mean Difference Mean ± SD
Unimodal Single style preference (V, A, R, K)	32.78 ± 6.97
Multimodal Two style preferences (VK, AK, RK)	34.37 ± 5.14
Multimodal Three style preferences (VAK, VRK, ARK)	31.93 ± 6.36
Multimodal Four style preferences (VARK)	35.00 ± 6.68

**Notes**: The *p*-value for the mean differences scores between the single style preference, two style preferences, three style preferences, and four style preferences was p > 0.05. **Abbrevation**: V, visual; A, aural; R, read/write; K, kinesthetic.

# Discussion

The current study aimed to investigate learning style preferences, the effects of learning in medical biochemistry by teaching based on the VARK learning style, and the relationship between the type and number of VARK learning styles and the medical biochemistry achievement of medical students at Walailak University. The results showed that medical students preferred a multimodal learning style more than a unimodal learning style. The medical students preferred four learning styles (VARK) more than two and three learning styles. These results are similar to a learning style preference of undergraduate dental students at King Saud University and undergraduate anatomy students at Indiana University who preferred four learning styles (VARK) more than two and three learning styles.<sup>19,20</sup> In this study, medical students preferred the kinesthetic learning style more than visual, aural, and read/write. These results differ from medical students at Urmia University of Medical Sciences, who preferred read/write learning styles more than other learning styles.<sup>21</sup> In addition, there are also differences from other field students, such as the read/write learning style being most preferred by dental students at Kermanshah University.<sup>22</sup> However, some students prefer kinesthetic learning styles more than other learning styles.

College and Hospital.<sup>20,23</sup> The above results from many studies indicated that the learning style preference of students is not associated with their field of study. The learning style preference of students may relate to other factors, such as learning experiences and course content. In addition, the learning style preferences of students in the same field of study differ among educational institutions. Therefore, although there has been previous research on the learning style preferences of students in each field of study, teachers should investigate the learning styles of students before starting each class. Some studies found that adapting teaching strategies to each student's preferred learning style enhances their comprehension, performance, and retention of the subject.<sup>7,8</sup> Therefore, teachers should pay attention to preparing a variety of teaching materials according to the students' learning styles.

All learning styles had a mean difference score (posttest scores minus pretest scores) above 27.00 (33.75%). Mean difference scores did not differ significantly between learning styles. All learning style preferences had a mean posttest score higher than a mean pretest score. Therefore, this result indicated that teaching based on the VARK learning style could enhance medical students' learning in all learning style preferences. However, the difference in learning style and the difference in number of learning styles were not significantly related to medical students' learning achievement in medical biochemistry. Previous studies also found that student performance and academic achievement were not significantly correlated with the VARK learning style in medical students<sup>17,24</sup> and anatomy students.<sup>20</sup> Mlambo<sup>25</sup> reported that the age, gender, entry qualifications, and learning style preferences of students were not significantly correlated with academic performance in an introductory biochemistry course at the University of the West Indies. Therefore, the learning achievement of medical students may be related to other factors rather than differences in learning styles.

Dong et al<sup>26</sup> found that there is a notable variation in the quality of learning engagement of students based on their past knowledge levels. Cai et al<sup>27</sup> found that explanation feedback was effective in enhancing the academic achievement of students in a technology-rich environment. In addition, the positive relationships between teachers and students could promote a helpful learning environment and improve students' academic achievement.<sup>28</sup> Therefore, the factors that effect to students' learning achievement may be impacted by prior knowledge and experience (ie what students already know about a subject — they might create connections and comprehend new material faster when they have prior knowledge), explanation feedback and assessment (students are able to understand their progress and make the required corrections to develop with the aid of frequent and constructive feedback as well as accurate assessment methods), classroom environment (while a stressful workplace may hinder achievement, a friendly setting of environment may encourage students' learning achievement), and teacher-student relationship (students can learn more from teachers who recognize and accommodate different learning styles).

## **Limitations and Future Direction**

The concept of learning styles suggests that individuals have unique preferences for how they best receive, process, and retain information. Since Coffield et al<sup>29</sup> reviewed learning styles, the status of instruments such as VARK in educational psychology and learning science has remained contentious because some studies have failed to find consistent evidence that matching teaching methods to an individual's learning style improves learning outcomes. However, knowledge of learning styles and approaches can be used in order to design curriculum that is effective for most students.<sup>16</sup>

The results of this study have some limitations. First, this is a study of a single institution; therefore, the sample in this study lacks diversity. The learning style preferences of students can vary among different demographic groups. Therefore, the results may not be applicable to students at different institutions or settings. Second, this study was teaching based on the VARK learning style by providing teaching materials according to the learning style for all students. Therefore, there was no control group in each learning style. However, the use of a control group would have increased the reliability, validity, and generalizability of meaningful conclusions about the effectiveness of leveraging learning styles. Third, this research is a study of short-term learning outcomes; research may not fully capture the more complex and wide-ranging implications of learning styles on education. In addition, studying during the COVID pandemic using online learning than onsite learning. The last limitation is that the VARK model focuses on how learners obtain information, but this model does not address cognitive processes, such as critical thinking and metacognition. As a consequence, this limitation may be a topic for future research.

# Conclusion

The medical students at Walailak University preferred a multimodal learning style more than a unimodal learning style. Among the multimodal learning styles, using four learning styles (VARK) was the most preferred method. The kinesthetic learning style was preferred by medical students more than visual, aural, and read/write for both unimodal and multimodal learning styles. Teaching based on the VARK learning style by providing teaching materials according to the learning style could enhance medical students' learning in medical biochemistry because all learning styles have higher posttest scores compared to pretest scores by approximately 33.75%. In addition, the difference in learning style and the difference in number of learning styles (single, two, three, and four style preferences) were not significantly related to medical students' learning achievement if they received teaching materials according to their learning styles. The knowledge of learning styles and approaches may be used as a guideline to provide a variety of teaching materials according to the learning style preferences of students for reviewing lessons.

# Ethics Statement

The ethics committee of Walailak University approved the study with the code WUEC-21-053-01.

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