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The Impact of Learning Styles on Academic Achievements among Undergraduate Mansoura Medical Students and Its Relation to Teaching Methods: A Cross-Sectional Study

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Abstract

Background:
Learning styles are habits the learners adopt to perceive, analyze, and interpret their knowledge. The aim of the present cross-sectional study is to determine the impact of the learning styles on academic achievements and assess its relation to teaching methods.

Method:
Fifth-year medical students from Mansoura University's conventional and Manchester programs, Egypt, answered learning style scales (VARK questionnaire) and an additional questionnaire concerning the various teaching methods. Furthermore, Students' academic achievement data were obtained from the Grade Center (semester 9: 2023–2024).

Results:
The results revealed that the unimodal learning style was adopted in 46% and 49.6% of students while the multimodal styles were adopted by 54% and 50.4%, in conventional and Manchester students, respectively. The preferred modes of learning by unimodal students were mostly kinesthetics in both programs. Among conventional program students, 63.6% preferred interactive lectures, whereas 71% of Manchester program students favored themed case discussions. High-achieving students obtained grade A, in both educational programs were strongly associated with kinesthetic learning styles and interactive lectures.

Conclusion:
This study highlights the crucial role of recognizing learning styles to optimize academic achievements among medical students and warrants further investigation for tailoring learning policies in medical education.

Keywords:
VARK; Learning styles; Teaching Methods; Conventional Program; Manchester Program.

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Introduction:

Learning styles are habits the learners adopt to perceive, analyze, and interpret their knowledge. Each student has his preferred learning style, which is usually determined by his type of personality or how he conceives learning and the environment they are placed in [1].

Knowing the student's learning styles can help teachers make learning more effective, as no single teaching method can meet the needs of all students [2]. Furthermore, understanding the learning styles of students can assist teachers in reinforcing their preferred learning styles and enhancing their less preferred styles. Adapting the curriculum to align with students' learning preferences and styles has the potential to improve their motivation and performance [3].

Learning styles are widely used in psychology and education to determine how individuals learn most effectively. VARK, which stands for visual, auditory, reading/writing, and kinesthetic learning preferences, provides a structured framework for classifying students based on their preferred learning methods [4].

Visual learners learn best by seeing. They find graphic displays such as charts, diagrams, illustrations, handouts, and helpful learning tools helpful and useful. Auditory learners prefer listening to class lectures instead of reading from the textbook or listening to podcasts instead of reviewing their class notes. Reading and writing learners enjoy taking in information displayed as words; they like making lists and reading definitions. Kinesthetic learners prefer performing tasks that involve directly manipulating objects and materials. They excel in practical activities and require hands-on practice to learn effectively [5].

Medical students during their course of study are exposed to various teaching methods like lectures, lab work, small group discussions, case-based learning, problem-based learning, and bedside teaching. Those methods change as they progress from the preclinical to clinical years of study [2].

Understanding the interrelation between learning styles and teaching methods is essential for improving academic achievement. Aligning teaching methods with diverse learning styles can significantly enhance student engagement and mastery of the material, leading to better academic outcomes [6] and improving overall educational experiences [7].

Students' academic achievements can be assessed using many methods, including their problem-solving abilities, clinical performances in fieldwork, grade point average (GPA), and the completion of an academic course [8].

The education system has strived to provide equal learning opportunities to all students, employing various approaches. However, despite numerous studies on student perception of information, there is still a fundamental issue within education, a conflict between teaching methods and learning styles. So, the present work aimed to determine the impact of the learning styles of fifth-year undergraduate medical students in Mansoura University in both conventional and Manchester programs on their academic achievements and assess its relation to teaching methods. Fifth-year students were selected for this study because they were expected to have achieved sufficient academic maturity to provide informed reflections on their preferred learning styles and teaching methods after four years of medical education. The study questions are:

• Do students' learning styles affect their preferred teaching methods?

• Do students' learning styles affect their academic achievements?

Subjects and methods

After providing informed consent, a convenience sample of fifth-year medical students from Mansoura University's Conventional and Manchester Medical Programs participated in this cross-sectional study during the 2023–2024 academic year. The Institutional Research Board (IRB) provided approval code (R.24.06.2654).

We distributed questionnaires to identify the students' learning styles based on the VARK scale and the preferred teaching methods to a sample of fifth-year medical students. The responders were 110 students of the conventional and 111 of the Manchester programs.

Inclusion criteria:

Medical students in the fifth year in Mansoura University's Conventional and Manchester Programs.

Exclusion criteria:

All medical students of other levels (first, second, third and fourth year) and all students who did not answer the questionnaire or did not answer the questionnaire appropriately.

Methods:

Mansoura University's Conventional and Manchester Medical Programs differ in their educational systems. While both programs share similarities, such as utilizing interdepartmental lectures, bedside training, clinical seminars, skill labs, and virtual labs, there are some dissimilarities. The field visits are present only in the Conventional program, whereas clinical debriefs, clinical placements, themed case discussions, and journal clubs are provided to the Manchester medical students.

Based on the previously mentioned difference in the teaching methodology between the two educational systems, we divided the study participants into two groups: the conventional program and the Manchester program.

All students first answered learning style scales; the latest English version of the VARK questionnaire was used in this study (VARK 8.01) and distributed to all students as Google Form. It is an instrument proposed by Fleming [9]. The VARK questionnaire was selected to identify an individual's preferred learning style across four modalities. Firstly, Visual (V) learners prefer learning through visual aids such as diagrams, charts, and maps. Secondly, Aural or Auditory (A) learners learn mainly via listening, discussions, and spoken explanations. Thirdly, Read/Write (R) learners prefer learning via reading and writing, including note-taking and textbook study. Finally, Kinesthetic learners (K) learn best through hands-on activities, experiments, and real-world experiences. When interpreting the results, a single dominant preference indicates that the learner benefits most from one of the previously mentioned styles. While a multimodal type indicates that the learner can effectively utilize multiple learning styles. To determine an individual's score for each category, the number of times each VARK letter is circled by the student is counted. Finally, we use The VARK Questionnaire – Scoring Chart to find the VARK category as fully illustrated on the following website: https://vark-learn.com.

The VARK Questionnaire was selected because it is reliable, concise, and easy to complete. It consists of 16 questions with 4 options each. Students were allowed to choose multiple answers per item to adequately describe their preferred response(s) to the situation.

Teaching methods were assessed by an additional questionnaire given to students through Google Form to determine the teaching methodology that is preferred by each student. The student had the freedom to select more than one option.

Academic achievement was collected from the Grade Center concerning the fifth year of both programs (semester 9).

Statistical Methods:

Collected data were revised, coded, tabulated and introduced to a PC using Statistical Package for Social Science (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). Data were presented and suitable analyses were performed according to the type of data obtained for each parameter. Kolmogorov-Smirnov test was used as a test of normality, if the significance level is greater than 0.05, then normality is assumed. Mean ± standard deviation (SD) and range were used for quantitative data. Frequency and percentage were used for categorical data. Chi-Square test was used to examine the relationship between two or more qualitative variables. Monte-Carlo test was used to examine the relationship between two groups with qualitative variables when the expected count is more than 5 in more than 20% of cells. In all applied tests, the P-values associated with test statistics indicated the significance level at which the null hypothesis (the hypothesis of no difference) was rejected, and P value of ≤ 0.05 is considered as an indication for a statistically significant result.

Results:

In the study, all medical students were in similar age group (around 23 years) and in conventional program the males were 50 students (45.4%) and the females were 60 students (54.6%). While in Manchester program the males were 71 students, and the females were 40 students (63.9% and 36.1 % respectively) (Table 1).

Table 1: Age and gender of the studied medical students in both programs.

	Conventional students (n=110)	Manchester students (n=111)
Age (year)		
Mean±SD	23±0.54	23±0.67
Gender		
Males	50 (45.4%)	71 (63.9%)
Females	60 (54.6%)	40 (36.1 %)
	Test of significance	
	$\chi^2 = 7.640$ P < 0.01*	

n: number; (%): percentage; χ^2: Chi square test *: Statistically significant (P < 0.05). SD: standard deviation

As shown in Figures 1 and 2, among the medical students of conventional program, the analysis of learning styles of responders revealed that 45.4% of the participated students had a unimodal style while 54.6% were multimodal (35% Bi response, 12% Tri-response, 7.6% Quadri-response). The preferred modes of learning by unimodal students in order were kinesthetics (29.1%), aural (12.7%), read/write (1.8%) and visual (1.8%).

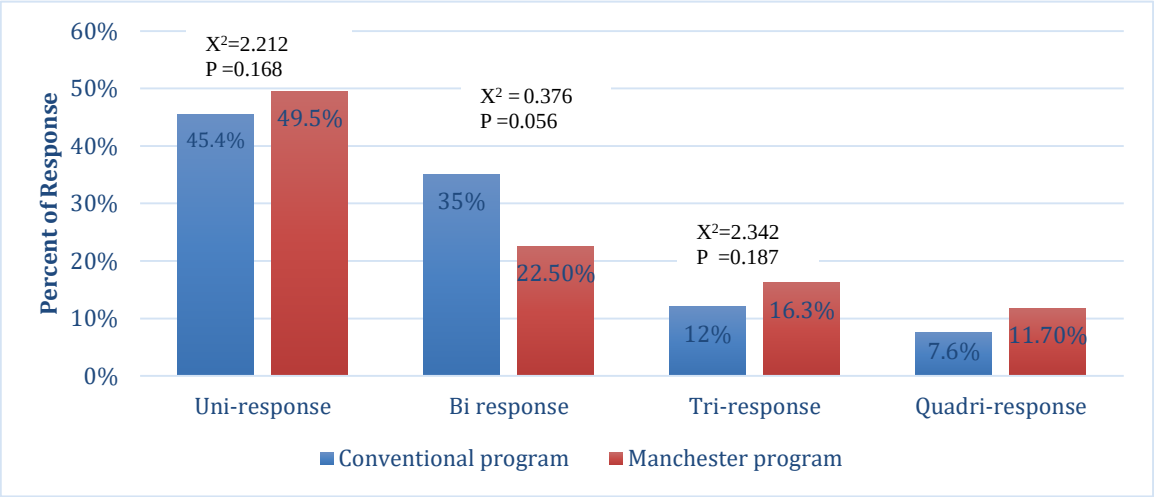

Fig.1: Distribution of learning style responses in conventional and Manchester programs

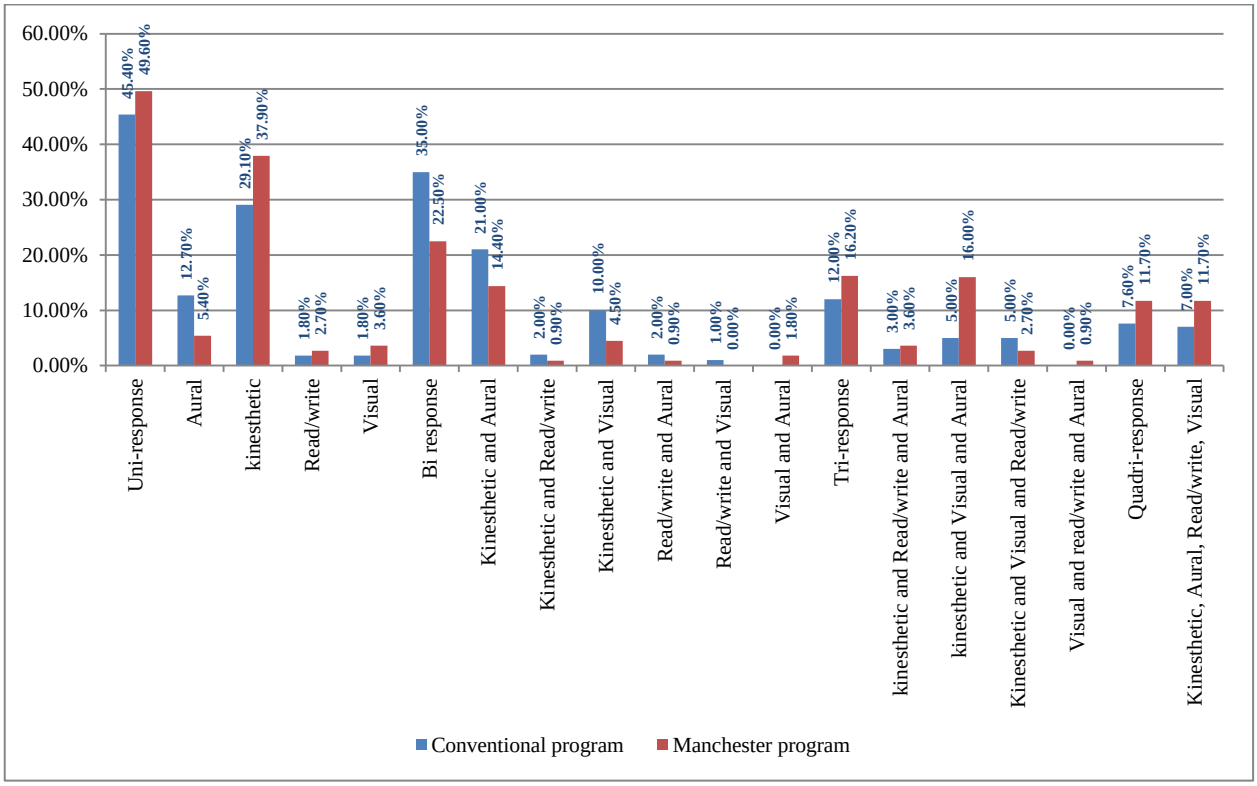

Fig.2: Distribution of uni-responses learning styles in conventional and Manchester programs

Regarding the medical students of Manchester program, the analysis of learning styles of responders revealed that 49.5% of the participated students had a unimodal style while 50.5% were multimodal (22.5% Bi response, 16.3% Tri-response, 11.7% Quadri-response). Preferred modes of learning by unimodal students in order were kinesthetics (37.8%), aural (5.4%), visual (3.6%) and read/write (2.7%). There were no statistical differences between the results in both schools.

In Figure 3, the analysis of preferred teaching methods questionnaire revealed that students in the conventional program, the most preferred teaching methods were interactive lectures (63.6%) and clinical skill labs (62.7%), while in the Manchester program were themed case discussions (71%) and small group discussions (55.9%).

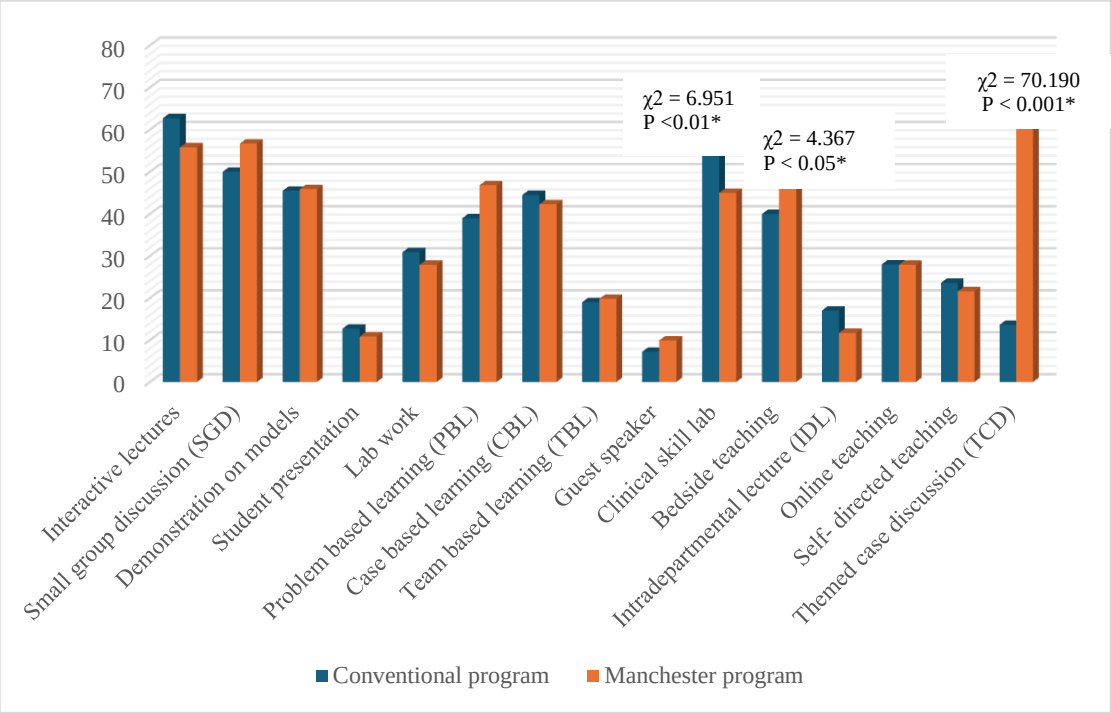

Fig.3: Distribution of preferred teaching methods in conventional and Manchester programs

There were significant differences between both groups regarding clinical skill lab, bedside teaching and themed case discussion (TCD) (P <0.01*, P < 0.05* and P < 0.001* respectively)

Table 2 shows the academic achievement grades of the medical students, 68.2% of the conventional program students obtained an A grade while 57.6% of the Manchester program students obtained an A grade. There were statistically significant differences between both programs regarding the different academic achievement grades (P < 0.001*).

Table 2: Students' academic achievement grades in both programs.

Academic achievement grades in both programs								
Conventional program (n=110)				Manchester program (n=111)				Test of significance
Grade	A	B	C	A	B	C	D	MC= 23.136 P < 0.001*
Number	75 (68.2%)	32 (28.2%)	3 (3.6 %)	64 (57.6%)	20 (18%)	21 (18.9%)	6 (5.4%)	

n: number. %: percentage. MC: Monte-Carlo test*: Statistically significant (P < 0.05).

Table 3 shows the association between the academic achievement grades and students' learning styles in conventional students. The highest percentage of grade A score is associated with Kinesthetic (K) learning style (30.7% of total grade A percentage) then Kinesthetic and Aural (KA) (24% of total grade A percentage). There were significant differences among conventional students' academic achievement grades regarding the K and KA learning styles (P< 0.05*).

Table 3: The association between students' academic achievement grades and their learning style in conventional students' group.

Students' academic achievement grades		Conventional students' group (n=110)			Test of significance (Chi square test) X^2
		A 75 (100%)	B 32 (100%)	C 3 (100%)	
Learning Styles	A	11 (14.7)	3(9.4)	0	X^2 = 1.015, P=0.602
	K	23 (30.7)	8 (25)	1 (33.3)	X^2 = 0.376, P< 0.05*
	R	1 (1.3)	1 (3.1)	0	X^2 = 0.460, P=0.794
	V	1 (1.3)	1 (3.1)	0	X^2 = 0.460, P=0.794
	KA	18 (24)	5 (15.6)	0	X^2 = 0.334, P<0.05*
	KR	2 (2.7)	0	0	X^2 =0 .951, P=0.622
	KV	6 (8)	4 (12.5)	1 (33.3)	X^2 = 2.370, P=0.306
	RA	1 (1.3)	1 (3.1)	0	X^2 = 0.460, P=0.794
	RV	0	1 (3.1)	0	X^2 = 2.460, P=0.292
	VA	0	0	0	-
	KRA	2 (2.7)	1 (3.1)	0	X^2 = 0.104, P=0.949
	KVA	2 (2.7)	2 (6.3)	1 (33.3)	X^2 = 0.555, P=0.652
	KVR	2 (2.7)	3 (9.4)	0	X^2 = 2.473, P=0.290
	VRA	0	0	0	-
	KARV	6 (8)	2 (6.3)	0	X^2 =0 .344, P=0.842

n: number. %: percentage. $\chi 2$: Chi square test *: Statistically significant (P < 0.05).
A (Aural), K (kinesthetic), R (Read/write), V (Visual)

Table 4 shows the association between the academic achievement grades and students' learning styles in Manchester students. The highest percentage of grade A score is associated with K learning style (46.9% of total grade A percentage) then KA (12.5% of total grade A percentage). There were significant differences among Manchester students' academic achievement grades (P<0.05*) regarding the K, KA and KARV learning styles.

Table 4: The association between students' academic achievement grades and their learning style in Manchester students' group.

Students' academic achievement grades		Manchester students' group (n=111)				Test of Significance (Chi square test) X^2
		A 64 (100%)	B 20 (100%)	C 21 (100%)	D 6 (100%)	
Learning Styles	A	4 (6.3)	2 (10)	0	0	X^2 = 2.458, P=0.483
	K	30 (46.9)	8 (40)	3 (14.3)	1 (16.7)	X^2 = 8.358, P<0.05*
	R	1 (1.6)	1 (5)	1 (4.8)	0	X^2 = 1.223, P=0.747
	V	2 (3.1)	1 (5)	1 (4.8)	0	X^2 = 0.460, P=0.928
	KA	8 (12.5)	3 (15)	4 (19)	1 (16.7)	X^2 = 8 .586, P<0.05*
	KR	1 (1.6)	0	0	0	X^2 = 0 .741, P=0.864
	KV	4 (6.3)	0	0	1 (16.7)	X^2 = 4.450, P=0.217
	RA	1 (1.6)	0	0	0	X^2 = 0 .741, P=0.864
	RV	0	0	0	0	---
	VA	0	1 (5)	1 (4.8)	0	X^2 = 3.481, P=0.323
	KRA	3 (4.7)	1 (5)	0	0	X^2 = 1.338, P=0.720
	KVA	3 (4.7)	2 (10)	5 (23.8)	0	X^2 = 7.688, P=0.053
	KVR	1 (1.6)	0	2 (9.5)	0	X^2 = 4.754, P=0.191
	VRA	0	0	1 (4.8)	0	X^2 = 4.325, P=0.228
	KARV	6 (9.4)	1 (5)	3 (14.3)	3 (50)	X^2 = 9.851, P<0.05*

n: number. %: percentage. $\chi 2$: Chi square test *: Statistically significant (P < 0.05).
A (Aural), K (kinesthetic), R (Read/Write), V (Visual)

Table 5 shows the association between conventional students' preferred teaching methods and their academic achievement grades. The students that achieved the highest-grade A chose interactive lectures and clinical skill lab as the most preferred teaching methods. There were significant differences among conventional students' academic achievement grades regarding the interactive lectures and clinical skill lab preferred teaching methods ($p<0.05$*).

Table 5: The association between students' preferred teaching methods and their academic achievement grades in conventional students' group.

	Students grading	Conventional students' group (n=110)			Test of Significance (Chi square test) X^2
		A 75 (100%)	B 32 (100%)	C 3 (100%)	
Teaching methods	Interactive lectures	46(61.3)	22(68.8)	2(66.7)	X^2 =6.545, p<0.05*
	Small group discussion	35 (46.7)	20 (62.5)	1 (33.3)	X^2 = 2.631, p=0.268
	Demonstration on Models	33 (44)	17 (53.1)	1 (33.3)	X^2 =0 .962, p=0.618
	Student Presentation	8 (10.7)	4 (12.5)	2 (66.7)	X^2 = 7.146, p=0.056
	Lab work	23 (30.7)	11 (34.4)	0	X^2 = 1.524, p=0.467
	PBL	29 (38.7)	12 (37.5)	2 (66.7)	X^2 =0 .998, p=0.607
	CBL	32 (42.7)	15 (46.9)	2 (66.7)	X^2 =0 .772, p=0.680
	TBL	12 (16)	8 (25)	1 (33.3)	X^2 = 1.581, p=0.454
	Guest Speaker	2 (2.7)	5 (15.6)	1 (33.3)	X^2 = 7.691, p=0.073
	Clinical skills Lab	46 (61.3)	23 (71.9)	0	X^2 = 6.256, p<0.05*
	Bedside teaching	34 (45.3)	10 (31.3)	1 (33.3)	X^2 = 1.914, p=0.384
	Intradepartmental lecture	10 (13.3)	9 (28.1)	0	X^2 = 4.078, p=0.130
	Online teaching	20 (26.7)	11 (34.4)	0	X^2 = 1.869, p=0.393
	Self- directed learning	15 (20)	10 (31.3)	1 (33.3)	X^2 = 1.733, p=0.420
	TCD	12 (16)	3 (9.4)	1 (33.3)	X^2 = 1.668, p=0.434

n: number. %: percentage. χ2: Chi square test *: Statistically significant (P < 0.05).
A (Aural), K (kinesthetic), R (Read/Write), V (Visual)
PBL: Problem-based learning; CBL: case-based learning; TBL: team-based learning; TCD: themed case discussion

Table 6 shows the association between Manchester students' preferred teaching methods and their academic achievement grades. The students that achieved the highest-grade A chose TCD and interactive lectures as the most preferred teaching methods. There were significant differences among Manchester students' academic achievement grades regarding the TCD and interactive lectures preferred teaching methods ($p<0.05$*).

Table 6: The association between students' preferred teaching methods and their academic achievement grades in Manchester students' group.

	Students grading	Manchester students' group (n=111)				Test of Significance (Chi square test) X^2
		A 64 (100%)	B 20 (100%)	C 21 (100%)	D 6 (100%)	
Teaching methods	Interactive lectures	36 (56.3)	12 (60)	10 (47.6)	3 (50)	X^2 = 6.765, p<0.05*
	Small group discussion	35 (54.7)	10 (50)	12 (57.1)	5 (83.3)	X^2 = 2.165, p=0.539
	Demonstration on Models	27 (42.2)	8 (40)	12 (57.1)	3 (50)	X^2 = 1.718, p=0.633
	Student Presentation	6 (9.4)	1 (5)	3 (14.3)	2 (33.3)	X^2 = 4.257, p=0.235
	Lab work	16 (25)	5 (25)	7 (33.3)	3 (50)	X^2 = 2.115, p=0.549
	PBL	28 (43.8)	6 (30)	14 (66.7)	4 (66.7)	X^2 = 6.786, p=0.079
	CBL	29 (45.3)	4 (20)	11 (52.4)	3 (50)	X^2 = 5.332, p=0.149
	TBL	17 (26.6)	2 (10)	3 (14.3)	0	X^2 = 4.932, p=0.177
	Guest Speaker	6 (9.4)	1 (5)	1 (4.8)	3 (50)	X^2 = 6.985, p=0.074
	Clinical skills Lab	28 (43.8)	8 (40)	12 (57.1)	2 (33.3)	X^2 = 1.823, p=0.610
	Bedside teaching	33 (51.6)	12 (60)	13 (61.9)	3 (50)	X^2 =0 .972, p=0.808
	Intradepartmental lecture	4 (6.3)	5 (25)	2 (9.5)	2 (33.3)	X^2 =6.072, p=0.064
	Online teaching	14 (21.9)	8 (40)	8 (38.1)	1 (16.7)	X^2 = 4.070, p=0.254
	Self- directed learning	14 (21.9)	5 (25)	3 (14.3)	2 (33.3)	X^2 = 1.290, p=0.732
	TCD	47 (73.4)	12 (60)	15 (71.4)	4 (66.7)	X^2 =7.368,p<0.05*

n: number. %: percentage. χ2: Chi square test *: Statistically significant (P < 0.05).
A (Aural), K (kinesthetic), R (Read/Write), V (Visual)
PBL: Problem-based learning; CBL: case-based learning; TBL: team-based learning; TCD: themed case discussion

Table 7 shows the association between the students' preferred teaching methods and their learning styles of conventional students' groups. It revealed that CBL (M7), intradepartmental lecture (M12) and TCD (M15) teaching methods showed significant differences between all learning styles (p values 0.01*, 0.03* and 0.01* respectively) and the three teaching methods showed high frequency in K, KA and KV learning style

. **Table 7: The association between students preferred teaching methods and their learning styles in conventional students' group.**

	A	K	R	V	KA	KR	KV	RA	RV	VA	KRA	KVA	KVR	VRA	KARV	Sum	Test of significance (Chi square test), X^2
M1	9 (64)	21 (65)	2 (100)	2 (100)	12 (52)	2 (100)	5 (45)	1 (50)	0	0	2 (66)	5 (100)	2 (40)	0	7 (87)	70	14.31 (0.281)
M2	4 (28)	15 (47)	2 (100)	1 (50)	16 (70)	2 (100)	5 (46)	0	1 (100)	0	2 (67)	3 (60)	2 (40)	0	3 (37)	56	14.51 (0.269)
M3	3 (21)	12 (37)	1 (50)	2 (100)	14 (61)	1 (50)	7 (64)	0	0	0	2 (67)	4 (80)	3 (60)	0	2 (25)	51	17.32 (0.138)
M4	4 (29)	2 (6)	0	0	1 (4)	1 (50)	1 (9)	1 (50)	0	0	1 (33)	2 (40)	1 (20)	0	0	14	17.59 (0.129)
M5	4 (29)	7 (22)	0	1 (50)	7 (30)	0	4 (36)	1 (50)	1 (100)	0	3 (100)	1 (20)	3 (60)	0	2 (25)	34	15.21 (0.230)
M6	3 (21)	8 (25)	1 (50)	0	11 (48)	1 (50)	6 (54)	1 (50)	1 (100)	0	2 (67)	3 (60)	3 (60)	0	3 (37)	43	12.28 (0.423)
M7	4 (29)	13 (57)	0	0	7 (22)	2 (100)	8 (73)	2 (100)	1 (100)	0	2 (67)	4 (80)	3 (60)	0	3 (37)	49	26.19 (0.01*)
M8	5 (36)	2 (6)	0	1 (50)	4 (17)	1 (50)	2 (18)	0	1 (100)	0	1 (33)	2 (40)	1 (20)	0	1 (12.5)	21	15.66 (0.207)
M9	0	3 (9)	0	0	3 (13)	0	1 (9)	0	0	0	0	1 (20)	0	0	0	8	5.65 (0.932)
M10	8 (57)	17 (53)	2 (100)	1 (50)	14 (61)	2 (100)	5 (45)	1 (50)	1 (100)	0	3 (100)	3 (60)	4 (80)	0	8 (100)	69	13.32 (0.346)
M11	2 (14)	14 (44)	0	1 (50)	11 (48)	0	6 (54)	1 (50)	0	0	1 (33)	3 (60)	1 (20)	0	5 (62)	45	12.38 (0.415)
M12	0	4 (13)	0	1 (50)	4 (17)	1 (50)	2 (18)	0	1 (100)	0	1 (33)	2 (40)	1 (20)	0	2 (25)	19	22.64 (0.03*)
M13	3 (21)	8 (25)	1 (50)	1 (50)	5 (22)	1 (50)	3 (27)	1 (50)	0	0	1 (33)	2 (40)	3 (60)	0	2 (25)	31	6.15 (0.908)
M14	2 (14)	7 (22)	0	0	4 (17)	1 (50)	3 (27)	1 (50)	1 (100)	0	1 (33)	2 (40)	1 (20)	0	3 (37)	26	9.12 (0.694)
M15	1 (7)	5 (15)	0	0	3 (13)	1 (50)	1 (9)	0	1 (100)	0	0	3 (60)	1 (20)	0	0	16	25.58 (0.01*)

n: number. %: percentage. $\chi 2$: Chi square test *: Statistically significant ($P < 0.05$).

M1: Interactive lectures, M2: small group discussion, M3: demonstration on models, M4: student presentation M5: lab work, M6: PBL, M7: CBL, M8: TBL, M9: guest speaker, M10: clinical skill lab, M11: bedside teaching M12: intradepartmental lecture, M13: online teaching, M14: self-directed teaching, M15: TCD

A (Aural), K (kinesthetic), R (Read/Write), V (Visual)

Table 8 shows the association between the students' preferred teaching methods and their learning styles in the Manchester students' group. The Manchester students' group showed a significant difference between all learning styles and small group discussion (M2), demonstration on models (M3), student presentation (M4), intradepartmental lecture (M12) and self-directed teaching (M14) teaching methods (p values 0.03*, 0.03*, 0.02*, 0.02* and 0.01* respectively). All these methods of teaching showed high frequency in A, K, KA, KVA and KARV learning styles.

Table 8: The association between the students' preferred teaching methods and their learning styles in Manchester students' group.

	A	K	R	V	KA	KR	KV	RA	RV	VA	KRA	KVA	KVR	VRA	KARV	Sum	Test of significance (Chi square test), X^2
M1	3 (50)	20 (48)	2 (67)	3 (75)	11 (69)	1 (100)	3 (60)	0	0	0	1 (25)	6 (60)	0	1 (100)	10 (77)	61	16.11 (0.243)
M2	5 (83)	16 (38)	0	1 (25)	11 (69)	1 (100)	5 (100)	1 (100)	0	2 (100)	2 (50)	7 (70)	1 (33)	1 (100)	9 (69)	62	23.96 (0.03*)
M3	0	15 (36)	1 (33)	0	9 (56)	0	3 (60)	0	0	0	3 (75)	8 (80)	2 (67)	1 (100)	8 (62)	50	23.98 (0.03*)
M4	1 (17)	2 (5)	0	1 (25)	2 (12)	0	0	0	0	0	0	0	0	1 (100)	5 (38)	12	24.76 (0.02*)
M5	2 (33)	6 (14)	2 (67)	1 (25)	5 (31)	0	3 (60)	0	0	0	1 (25)	3 (30)	1 (33)	1 (100)	6 (46)	31	15.22 (0.294)
M6	1 (17)	16 (38)	0	2 (50)	9 (56)	1 (100)	2 (40)	1 (100)	0	1 (50)	1 (25)	8 (80)	1 (33)	1 (100)	8 (62)	52	16.74 (0.211)
M7	2 (33)	14 (33)	0	0	9 (56)	0	3 (60)	1 (100)	0	1 (50)	1 (25)	5 (50)	2 (67)	1 (100)	8 (62)	47	15.57 (0.273)
M8	2 (33)	6 (14)	0	0	7 (44)	0	1 (20)	0	0	0	1 (25)	0	0	1 (100)	4 (31)	22	18.29 (0.147)
M9	1 (17)	2 (5)	1 (33)	0	0	0	1 (20)	0	0	0	1 (25)	0	0	0	5 (39)	11	21.03 (0.072)
M10	2 (33)	17 (40)	1 (33)	1 (25)	10 (62)	0	3 (60)	1 (100)	0	1 (50)	1 (25)	4 (40)	2 (67)	1 (100)	6 (46)	50	8.52 (0.808)
M11	4 (67)	20 (48)	2 (67)	1 (25)	7 (44)	1 (100)	2 (40)	1 (100)	0	1 (50)	2 (50)	6 (60)	2 (67)	1 (100)	11 (85)	61	11.53 (0.566)
M12	3 (50)	2 (5)	1 (33)	0	2 (12)	0	0	0	0	0	1 (25)	0	0	1 (100)	3 (23)	13	25.12 (0.02*)
M13	3 (50)	4 (9)	1 (33)	1 (25)	6 (37)	0	1 (20)	1 (100)	0	1 (50)	1 (25)	4 (40)	0	1 (100)	7 (54)	31	21.74 (0.060)
M14	4 (67)	4 (9)	0	1 (25)	1 (6)	1 (100)	1 (20)	1 (100)	0	0	2 (50)	3 (30)	0	0	6 (46)	24	29.74 (0.01*)
M15	4 (67)	33 (79)	1 (33)	1 (25)	12 (75)	1 (100)	3 (60)	1 (100)	0	1 (50)	2 (50)	6 (60)	2 (67)	0	11 (85)	78	13.92 (0.379)

n: number. %: percentage. $\chi 2$: Chi square test *: Statistically significant ($P < 0.05$). M1: Interactive lectures, M2: small group discussion, M3: demonstration on models, M4: student presentation M5: lab work, M6: PBL, M7: CBL, M8: TBL, M9: guest speaker, M10: clinical skill lab, M11: bedside teaching M12: intradepartmental lecture, M13: online teaching, M14: self-directed teaching, M15: TCD, A (Aural), K (kinaesthetic), R (Read/Write), V (Visual)

Discussion

It has been argued that knowledge of learning styles can be useful to both teachers and students. Teachers can tailor pedagogy to correlate with the preferred students' learning styles [10]. Similarly, students with knowledge of their learning styles could be strengthened to identify and use the techniques of learning best suited to their styles, resulting in greater educational satisfaction [11].

The present work aimed to determine the impact of the learning styles of fifth-year undergraduate medical students in Mansoura University in both conventional and Manchester programs on their academic achievements and study its relation to different teaching methods.
The participants in this study were in a similar age group (around 23 years) and in conventional program the males presented 45.4% and the females presented 54.6%. While in Manchester program the males and females presented 63.9% and 36.1 % respectively.

Regarding the distribution of student samples, some studies have addressed almost similar topics as in a study involving 298 undergraduate dental students from years 1 to 5, with 64.43% were female students and 35.57% were male students, to explore the predominant learning styles and their influence on the academic performance of dental students, AIMST University, Malysia [12] and Ariastuti and Wahyudin [13] explored the students' academic performance and its relation to different learning style preference at undergraduate level involving 39 students of English Education major in a university in Lampung (30% male, 69% female).

Determining students' learning styles provides information about their specific preferences. Understanding learning styles can make creating, modifying, and developing more efficient curricula and educational programs easier. It can also encourage students' participation in these programs and motivate them to gain professional knowledge [14].

In the present study we distributed questionnaires to identify the students' learning styles based on the VARK scale and the preferred teaching methods. The use of VARK allows a better understanding of information-processing preferences, including a learner's ability to use more than one learning mode simultaneously [15].

The present results showed that according to the students of conventional program, the analysis of learning styles of responders revealed that the highest ratio was the multimodal learning styles (54.6%) then 45.4% of the participated students had unimodal style. Regarding the students of Manchester program, the analysis of learning styles of responders revealed the same as conventional students (50.5% were multimodal) and (49.5% were unimodal style). The highest mode of learning by unimodal learning styles was kinesthetic in both conventional and Manchester programs (29.1% and 37.8% respectively).

Similar results were revealed in a study conducted by Kharb et al. [16] which demonstrated kinesthetic strategy or learning style as the most favored learning method by the students. Also, Mashhood et al. [17] in their study found that the kinesthetic learning style was the most preferred learning style of the medical students of Karachi Medical and Dental College, Karachi.

In contrast, a study carried out by Fleming [9] found that 40% of participants who completed the questionnaire online preferred to learn using all VARK modes. In addition, Nuzhat et al. [18] examined the learning style preferences of undergraduate medical students in King Saud Bin Abdul Aziz University for Health Sciences, King Fahad Medical College, Saudi Arabia. It demonstrated that 22.6% of students preferred to learn using all VARK modalities. Among the single learning modalities, researchers found that 11.6% of these students preferred learning using the aural mode.

In addition, in a research project done by Almigbal [3] on medical students at King Saud University in Riyadh, Kingdom of Saudi Arabia found that a large portion of the medical students who participated in his study preferred to learn using all VARK modalities (43.5%). The second highest group was students who preferred to learn using aural modalities (21.2%).

In our study, the analysis of preferred teaching methods questionnaire revealed that in the conventional program, the most preferred teaching methods were interactive lectures and clinical skill labs, while in the Manchester program were themed case discussions and small group discussions. In our opinion this variation in preferences indicates that students are not only aware of their learning styles but also actively seek out teaching methods that align with those styles.

Koh et al. [19] stated that teaching medicine is a constantly changing process requiring students and teachers continuously update themselves. The challenge of imparting a large amount of knowledge within a limited time in a way that is retained, remembered, and effectively interpreted by a student is considerable. This has resulted in crucial changes in the field of medical education, with a shift from didactic teacher-centered and subject-based teaching to interactive, problem-based, student-centered learning. Most medical school curricula have adopted new teaching and learning methods to varying degrees.

In accordance, Alfarsi et al. [15] concluded that the teaching method preferred by most of the students at the College of Medicine and Health Sciences, Sohar, Oman included clinical skills lab (64%) followed by interactive lecture (59%) and lab work (57%).

One of the primary findings of this study is students who were identified as kinesthetic learning styles adopters achieved higher academic grades (30.7% of conventional program

students and 46.9% of Manchester program students obtaining grade A scores). The results underscore the necessity for educators to incorporate active learning strategies into their teaching methodologies to cater to the needs of kinesthetic learners.

In contrast, a study done by Lujan and DiCarlo [20], found multi-modal learners to have better academic results than uni-modal learners in Department of Physiology, Wayne State University School of Medicine, Detroit, Michigan. Also, Alkhasawneh et al. [21] who identified a significant relationship between VARK preferences and course grades. In addition, Akhlaghi et al. [22] concluded that in their study there was a significant association between academic performance and reading-writing learning style preference. Plus, Gurpinar et al. [23] who did not find a relationship between learning styles and academic grades in their studies of undergraduate medical students. In addition, Urval et al. [24] in their study, performed at the Department of Pharmacology at Kasturba Medical College. Five hundred undergraduate students in two consecutive batches in their second year of graduate medical training found no statistical association between learning style preferences and academic performance based on grades. In addition, Almigbal [3] concluded that there was no relationship between learning style preferences and academic achievement in his study on students at medical college at King Saud University in Riyadh, KSA.

The present results showed a significant association between the students that achieved the highest-grade (A) and (interactive lectures and clinical skill lab) as the preferred teaching methods in conventional program, and (TCD and interactive lectures) in Manchester program. The significant association between preferred teaching methods and academic achievement suggests that educators should be mindful of these preferences when designing curricula and instructional activities. By aligning teaching methods with academic achievement, educators can enhance student engagement, satisfaction, and ultimately, academic success.

In accordance, Ganyaupfu [25] concluded that the performance assessment scores of students differed significantly among the three teaching methods (teacher centered, student centered, teacher-student interactive).

In the present work, the association between the students' preferred teaching methods and their learning styles of conventional students' group, revealed that CBL, intradepartmental lecture and TCD teaching methods showed significant differences between all learning styles and presented mostly in the K, KA and KV learning styles.

While, in Manchester students' group, small group discussion, demonstration on models, student presentation, intradepartmental lectures and self-directed teaching showed significant differences between all learning styles and presented mostly in A, K, KA, KVA and KARV learning styles.

In accordance, Kharb et al. [16] found a correlation between the preferences of the VARK modes and the teaching methods. In contrast, Loo [26] examined the relationship between learning styles and learning preferences among undergraduate management students and found that there were weak relationship between learning styles and preferences.

This study has some limitations. Firstly, the relatively small sample size limited our ability to perform sub-stratification of the groups. Secondly, this study was conducted within a single semester at one university, which may limit the generalizability of the results.

Conclusion:

In conventional and Manchester programs in Mansura Medical School, the highest ratio was the multimodal learning styles and the preferred mode of learning by unimodal students is kinesthetics model.

The preferred teaching methods in the conventional program are interactive lectures and clinical skill labs while students in the Manchester program favored TCD and small group discussions.

The applied teaching methods in the Manchester program showed greater variety than in the conventional program.

The association between the academic achievement grades and students' learning styles showed the highest percentage of Grade A score is associated with Kinesthetic learning style then Kinesthetic and Aural (KA) in conventional and Manchester students.

The association between the academic achievement grades and the preferred teaching methods showed students that achieved the highest-grade (A) significantly associated with (interactive lectures and clinical skill lab) in conventional students, and (interactive lectures and TCD) in Manchester students.

The association between the students' preferred teaching methods and their learning styles of conventional students' group revealed that CBL, intradepartmental lecture and TCD teaching methods showed significant differences between all learning styles and presented mostly in the Kinesthetic, Kinesthetic and Aural (KA) , and Kinesthetic and visual (KV) learning styles. While, in Manchester students' group, small group discussion, demonstration on models, student presentation, intradepartmental lecture and self-directed teaching showed a significant difference between all learning styles and presented mostly in the A, K, KA, KVA, and KARV learning styles.

These results warrant further investigation and have the potential to significantly impact on the tailoring of learning policies in medical education field.

Recommendation:

We recommend assessing students' learning styles through different levels and in different universities from different regions with large samples.

The study emphasizes that understanding students' learning styles can help in tailoring teaching methods to enhance educational satisfaction and academic success. This suggests that educators can improve curriculum design and instructional strategies by considering the diverse learning preferences of students.

The study suggests that active learning strategies, which align well with kinesthetic preferences, should be integrated into the curriculum to enhance student engagement and academic performance. The students' learning styles of both programs were associated with the special teaching methods preferred by the students. These results are very useful for improving the quality of teaching and may impact how educators deliver information to students in the future.

Statements and declarations:

Ethics approval and consent:

This study was conducted following approval from the Institutional Review Board (IRB) of the Faculty of Medicine, Mansoura University (Approval No. R.24.06.2654) and informed consent was obtained from participants.

Availability of data and material:

- Data supporting the current study is provided as a supplementary file.
- Data supporting the current study will be available from the corresponding author upon a reasonable request.

Conflict of interests:

The authors declare that they have no conflict of interests.

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Authors contributions:

Prof. Dr. Afaf, Dr. Nermin, Dr. Dalia, Dr. Heba, and Dr. Mohamed contributed to the study design and the development of the protocol. Dr. Lamis and Manar assisted with the final revision of the manuscript. Prof. Dr. Afaf, Dr. Nermin, Dr. Dalia, Dr. Heba, Dr. Mohamed, and Abd Alrahman participated in data collection. Prof. Dr. Afaf conducted the data analysis. All authors contributed to data interpretation, manuscript writing, and revision. All authors have read and approved the final manuscript.

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