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The Relationship Between Preferred Learning Styles and Academic Achievement of Undergraduate Health Sciences Students Compared to Other Disciplines at a Middle Eastern University Utilizing the VARK Instrument

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Introduction: Learning style denotes a learner's approach to acquiring, processing, interpreting, organizing, and contemplating information. VARK, formulated by Fleming and Mills (1992), assesses learning styles: Visual (V), Aural (A), Reading/Writing (R), and Kinesthetic (K). Visual learners prefer observing; Aural learners favor listening to lectures; Reading/Writing learners engage through texts and notes; Kinesthetic learners benefit from tactile activities.

Purpose: To compare learning style preferences of undergraduate health sciences students with other disciplines and examine the relationship between VARK scores and academic performance.

Methods: A cross-sectional study of 347 undergraduate students recorded demographic data and responses to the Arabic version of the VARK questionnaire. Data were analyzed using SPSS version 27 which included descriptive and inferential statistics.

Results: Unimodal preferences were most common, ranging from 47.4% to 51.4% in the College of Health Sciences and 11.8% to 15.0% in the College of Law as the least. Quadmodal preferences were rare but more frequent in Health Sciences and Engineering. Auditory (A) was the most preferred unimodal style (Mean/SD - 3.72/2.181), while kinesthetic (Mean/SD - 0.54/.864) was the least preferred. Mann–Whitney *U*-test results indicated Health Sciences students scored higher in K ($Z = -4.558$, $p<0.001$) and total VARK scores ($Z = -3.633$, $p<0.001$). There was a statistically significant difference in CGPA between unimodal and multimodal learners ($Z = -2.150$, $p=0.032$), with unimodal learners ranking lower.

Conclusion: The findings suggest that multimodal learners outperformed unimodal learners, even though unimodal learners constituted a larger group. The Health Sciences and Engineering students exhibited marginally higher Quadmodal learning preferences than other disciplines, indicating the need for comprehensive and engaging learning experiences. These results have practical implications for educators, who should consider learning styles to enhance teaching strategies, address unique student challenges, and create an inclusive educational environment.

Keywords: learning style, VARK, academic achievement, health sciences, university, undergraduate students

Introduction

Education is the process of facilitating learning, which encompasses the acquisition of knowledge, skills, values, and habits.[1] Learning is a multifaceted process that is influenced by various factors, including the educational environment, the curriculum, the educator, and the student.[2] Factors that affect academic achievements, such as learning styles, are important considerations in the educational process.[3] Academic achievement is a critical predictor of future academic status, making it a crucial parameter for learners.[4] Learning style is defined as a combination of cognitive, emotional, and physiological traits that

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illustrates how the learner perceives and responds to the learning environment.[5] Understanding the learning style of learners can be effective in organizing and modifying the learning environment and teaching and learning process.[6]

Over the past few decades, medical education has rapidly shifted from a teacher-centered passive approach to a student-centered active approach. Thus, awareness about preferred learning styles can be useful for pupils and educators.[7] Instructors can modify their teaching strategies to align with the learners' preferences by incorporating various teaching styles. According to research, when instruction is tailored to a student's learning style, their motivation and performance improve.[8] Additionally, understanding one's learning style can help minimize the amount of time spent learning, increase engagement, and enhance learning outcomes and efficiency.[9] There are several methods to measure learning styles, and the VARK (an acronym for Visual, Aural, Read/write and Kinesthetic, learning styles) questionnaire developed by Fleming and Mills (1992) is the most widely used one.[10] Fleming primarily developed VARK based on his observations as a school inspector and interactions with students and teachers at Lincoln University of New Zealand.[11] VARK is a learning inventory grouped under the "instructional preference" model. VARK categorizes learning by sensory preferences.[12] Visual learners (V) prefer to learn by watching videos, images, figures, and flowcharts. Aural learners (A) like to process information by listening to lectures, tutorials, and seminars; reading-writing learners (R) prefer to read texts/written words repeatedly and write/take notes, and kinesthetic learners (K) prefer to learn by connecting to reality through touch and manipulation of objects, kinesthetic learners acquire information by experience and practice.[10,13] A learner's style preference can be unimodal or multimodal. Singular or unimodal with one main preferred modality: a multimodal pattern incorporates students who can acquire or process information through more than one style of learning. Multimodal includes bimodal, trimodal or quadmodal, bimodal with two preferences, trimodal with three, or quadmodal with the preference including of all four types.[14,15]

Numerous attempts have been made to improve the academic performance of students. There are various ways to measure students' academic performance, including their problem-solving skills, fieldwork clinical performance, Grade Point Average (GPA), and course completion.[16] As such, one of the most crucial responsibilities and challenges of instructors is to present information using a range of teaching methods because teaching and learning styles can impact student success. To be effective teachers, faculty members must possess content expertise, pedagogical knowledge, and knowledge of the learner's characteristics and learning preferences.[17]

Learning styles can differ from one student to another and can also change over time.[18] The brain's capacity to regenerate and develop over time can influence students' attitudes toward learning based on the insights they gain from their educational environment.[19]

Little is known about the distribution of learning style preferences among higher-education students in Oman, where culture and education differ significantly from those in Western countries. To address this gap, our study aimed to examine the preferred learning styles of health sciences students compared to other discipline students in a University in Oman. Additionally, we investigated the relationship between these preferences and students' academic performance.

Materials and Methods

Study Design

This descriptive cross-sectional study was conducted among undergraduate students at the University of Buraimi, Oman, during the fall semester between September and December 2023.

Sampling Technique

The convenience sampling technique, which is a non-probability sampling method in which the sample is easily approached, was implemented to collect data. This technique was employed because it saved time and effort, and it would have been difficult for the researcher to visit different colleges to access students. A total of 347 students from different colleges at the University of Buraimi in Oman completed the questionnaire survey.

Sample Size

The total number of undergraduate students registered in all four colleges, namely College of Health Sciences, College of Engineering, College of Law, and College of Business in the fall semester of 2023 are 2992.

The sample size is calculated using the OpenEpi software version 3 as follows:[20]

Sample size n = [DEFF*Np(1-p)]/[(d2 /Z2 1-α/2*(N-1)+p*(1-p)]

At the 95% confidence level and the 5% confidence limit, the estimated sample size was 341.

Ethical Considerations

Ethical Approval (approval No. AY21-22COHS-65) was received on 13/08/2022 from the Research and Ethics Committee, College of Health Sciences, University of Buraimi, Oman. This study was conducted following the Declaration of Helsinki. The ethical review application included a participant information sheet and a written informed consent form. The participant information sheet stated that student participation was purely voluntary and did not affect their assessment or performance. The informed consent form was provided to all the potential participants to read and fill out before completing the online questionnaire. The consent form included statements that their participation was completely voluntary, and they were free to withdraw at any stage of the study without being affected. The participants were also informed that their data would be treated with full confidentiality and were provided with written debriefing, which included a sheet that they could keep, which showed the explanations of the study. Written informed consent was obtained from all the students, and their confidentiality was ensured.

Data Collection Procedure

A survey was conducted using an anonymous online questionnaire to determine the preferred learning styles of undergraduate students. The initial introduction and objectives of the study were explained, followed by a statement of consent. All items were entered into Google Forms (Google LLC) and distributed to the students as a questionnaire link via Email through the student affairs department. Students were given the flexibility to respond to the survey at their leisure. Additionally, two Email reminders were sent at regular intervals. The data collection process was discontinued in December 2023 owing to the saturation point in sample size and time.

Instruments Used

The instruments were in two parts. Part 1: Students' demographic characteristics include age, gender, marital status, college, educational major, year of study, and Cumulative Grade Point Average. Students' names were not asked to maintain the anonymity of research and maintain participant confidentiality. Part 2: Learning Style Instrument, The VARK questionnaire for younger people: The VARK questionnaire is a standardized tool, whose both validity and reliability were assessed and confirmed in a 2018 study by Zhu.[21] We used the Arabic version of the VARK questionnaire (8.01 version) as the student's first language is Arabic.[22] Twenty-five % of the studies that used the Arabic version of the VARK instrument verified its reliability and validity.[23] The VARK questionnaire, as a learning preference assessment tool, consists of simple 16 multiple-choice questions, each having four choices. All choices correspond to the four sensory modalities that are measured by Visual, Aural/Auditory, Read/Write, and Kinesthetic (VARK). The respondents were permitted to choose one or more of the sensory modalities that they preferred. Each question was aimed at placing respondents in a "learning" situation. The distribution of VARK preferences was calculated according to the guidelines mentioned on the VARK website (https://vark-learn.com/).[24] Accordingly, learning preferences were categorized as unimodal (V, A, R, or K), bimodal (VA, VR, AR, VK, AK, and RK), trimodal (VAR, ARK, VRK, and VAK), or quadmodal (VARK).

Data Analysis

Data was entered into Microsoft Excel and transferred to SPSS for analysis. All analyses were performed using the IBM SPSS statistical software version 27 (IBM Corporation, New York, USA) and Microsoft Excel 2013 (Microsoft Corporation, Redmond, Washington, USA). The variables such as age, sex composition, marital status, college affiliation, and year of study were entered into Excel spreadsheets using numerical coding. Descriptive statistics such as frequency, percentage, mean, range, and standard deviation (SD) were derived, and tables were prepared to show the distribution of

data. The Kolmogorov–Smirnov and Shapiro–Wilk tests were applied to determine whether the variables followed a normal distribution. Further, the Mann–Whitney *U*-test, a non-parametric test, was used to assess differences between two independent groups, such as differences between binomial categorical variables (male vs female, unimodal vs multimodal learners). Finally, the correlations between variables were tested using the Spearman correlation test. All values were considered statistically significant at $P<0.05$. Outcome variables were VARK score, total V score, total A score, total R score, and total K score and CGPA.

The information provided was thoroughly scrutinized during the screening procedure for any miscalculations or discrepancies. Specifically, any form containing unclear or illogical responses to questions about the CGPA obtained in the most recent professional exam was excluded.

Results

The study involved 347 undergraduate students at the University of Buraimi in 2023. A comprehensive overview of the demographic variables of the study participants offered insights into age distribution, sex composition, marital status, college affiliation, and year of study. In terms of age, the majority fell within the 18–25 age range, with 42.9% aged 18–21 years and 44.1% aged 22–25 years. A smaller proportion represented individuals aged 26–33 years (2.3% to 6.9%), and 3.7% were 34 years and above. The gender distribution revealed a predominantly female population, constituting 90.5%, while males represented 9.5%. Marital status indicated that a significant portion of the respondents were single (87.9%), with a minority being married (11.0%) or divorced (1.2%). Academic affiliation is delineated by colleges, with the College of Health Sciences being the most represented at 55.3%, followed by the College of Engineering (27.1%), the College of Business (6.9%), and the College of Law (10.7%). Furthermore, the distribution by year of study indicates a fairly even spread, with 1st-year students comprising 21.3%, 2nd-year students at 24.2%, 3rd-year students making up 32.9%, and 4th-year students representing 21.6% of the surveyed population (Table 1).

Key descriptive statistics for the four distinct learning style scores (V, A, R, and K) and their cumulative total VARK scores are presented in Table 2. The mean values provide a central tendency for each score, revealing that, on average, respondents scored 2.34 in Visual (V), 3.72 in Auditory (A), 2.95 in Reading/Writing (R), and 0.54 in Kinesthetic (K), resulting in a mean Total VARK Score of 9.55. The median values, representing the midpoint, differed slightly from the mean values, indicating potential skewness in the data. The standard error of the mean values, which measures the precision of the sample mean, was relatively low across all scores, suggesting a degree of confidence in the reported means. The standard deviation values ranged from 1.805 to 2.862, indicating the extent of variability within each score. Additionally, variance values shed light on the spread of data, with higher variances indicating greater dispersion.

Table 1 Demographic Characteristics of the Respondents

Demographic Variables	Frequency	Percentage
Age		
18–21 years	149	42.9
22–25 years	153	44.1
26–29 years	8	2.3
30–33 years	24	6.9
34 and above	13	3.7
Sex		
Male	33	9.5
Female	314	90.5

(*Continued*)

Table 1 (Continued).

Demographic Variables	Frequency	Percentage
Marital Status		
Single	305	87.9
Married	38	11
Divorced	4	1.2
Colleges	Frequency	Percentage
College of Health Sciences	192	55.3
College of Engineering	94	27.1
College of Business	24	6.9
College of Law	37	10.7
Year of Study		
1 st Year	74	21.3
2nd Year	84	24.2
3rd Year	114	32.9
4 th Year	75	21.6

Table 2 Descriptive Characteristics for VARK Learning Style Scores

Descriptive Statistics		V SCORE	A SCORE	R Score	K Score	Total VARK Score
Mean		2.34	3.72	2.95	0.54	9.55
Std. Error of Mean		0.097	0.117	0.092	0.046	0.154
Median		2	4	3	0	10
Std. Deviation		1.805	2.181	1.72	0.864	2.862
Variance		3.259	4.758	2.957	0.746	8.19
Range		8	11	9	4	15
Minimum		0	0	0	0	1
Maximum		8	11	9	4	16
Percentiles	25	1	2	2	0	8
	50	2	4	3	0	10
	75	3	5	4	1	12

Table 3 presents a detailed breakdown of individuals' preferred learning styles across various scenarios, categorized into four modalities: unimodal, bimodal, trimodal, and quadmodal. In scenarios involving navigation to a recommended shop, viewing instructional videos on graph creation, researching a tour, and selecting a career or area of study, most respondents (ranging from 79.3% to 84.1%) express a preference for Unimodal learning – relying on a single mode such as text, visuals, or auditory information. For tasks related to decision-making, like saving money, choosing options, or learning a new board game, respondents exhibit a preference for Bimodal learning, combining two modes for a more comprehensive understanding.

Table 3 Students' Preferred Learning Styles in Four Modalities

VARK Questionnaire	Unimodal		Bimodal		Trimodal		Quadmodal	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Q1	284	81.8	54	15.6	8	2.3	1	0.3
Q2	292	84.1	46	13.3	7	2	2	0.6
Q3	287	82.7	41	11.8	18	5.2	1	0.3
Q4	288	83	48	13.8	8	2.3	3	0.9
Q5	275	79.3	62	17.9	6	1.7	4	1.2
Q6	260	74.9	74	21.3	11	3.2	2	0.6
Q7	258	74.4	72	20.7	9	2.6	7	2
Q8	249	71.8	76	21.9	18	5.2	4	1.2
Q9	246	70.9	68	19.6	27	7.8	6	1.7
Q10	247	71.2	71	20.5	16	4.6	13	3.7
Q11	227	65.4	88	25.4	26	7.5	6	1.7
Q12	262	75.5	69	19.9	9	2.6	7	2
Q13	234	67.4	81	23.3	23	6.6	9	2.6
Q14	283	81.6	49	14.1	7	2	5	1.4
Q15	245	70.6	74	21.3	24	6.9	4	1.2
Q16	234	67.4	79	22.8	24	6.9	10	2.9

Bimodal learning percentages range from 19.6% to 21.3%, indicating a significant but not predominant preference. Trimodal learning, incorporating three modes, becomes more prominent in scenarios such as dealing with health issues, computer learning, or seeking information on the Internet. Responses for Trimodal learning preferences range from 4.6% to 7.8%, reflecting a moderate inclination towards utilizing a combination of modes. Quadmodal preferences, involving all four modes, emerge in various contexts, including learning about a project, improving photography skills, and assembling a wooden table While quadmodal preferences are less common, ranging from 1.2% to 3.7%, they highlight instances where respondents find a comprehensive approach involving all four modes beneficial. Overall, the data reveal a diverse set of learning preferences, with the majority favoring unimodal and bimodal learning approaches.

A detailed analysis of learning modality preferences among students from Health Sciences, Engineering, Business, and Law for each of the 16 scenarios (Q1–Q16) shows frequency and percentage distributions. Unimodal preferences dominate across all colleges and scenarios, with percentages ranging from 47.4% to 51.4% in Health Sciences, 28.2% to 30.5% in Engineering, 7.3% to 8.5% in Business, and 11.8% to 15.0% in Law, reflecting a strong inclination for single learning modes. Bimodal preferences vary by scenario and college, with Business showing lower preferences (0.0% to 4.3%) compared to Health Sciences and Engineering, which exhibit higher bimodal preferences in collaborative or diverse scenarios. Trimodal preferences are less common, with Law consistently showing lower preferences (0.0% to 1.9%) and other colleges displaying slightly higher preferences, especially in comprehensive scenarios. Quadmodal preferences are the least common but present in certain scenarios, with Health Sciences and Engineering showing slightly higher preferences than Business and Law, indicating a need for fully immersive experiences. Overall, unimodal preferences prevail, with percentages from 47.8% to 51.4% across colleges. Bimodal preferences are notable in specific scenarios, while trimodal and quadmodal preferences, though less common, suggest openness to diverse learning approaches (Table 4).

Table 5 shows the Kolmogorov–Smirnov and Shapiro–Wilk normality test results for various variables, assessing if their distributions are normal. The Kolmogorov–Smirnov test statistics for CGPA, V SCORE, A SCORE, R Score, K Score, and Total

Table 4 Distribution of Learning Style Preferences Among Different Colleges

		College of Health Sciences		College of Engineering		College of Business		College of Law		Total
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	
Q1	Unimodal	146	51.4	80	28.2	22	7.7	36	12.7	284
	Bimodal	39	72.2	12	22.2	2	3.7	1	1.9	54
	Trimodal	6	75.0	2	25.0	0	0.0	0	0.0	8
	Quadmodal	1	100.0	0	0.0	0	0.0	0	0.0	1
Q2	Unimodal	147	50.3	86	29.5	24	8.2	35	12.0	292
	Bimodal	36	78.3	8	17.4	0	0.0	2	4.3	46
	Trimodal	7	100.0	0	0.0	0	0.0	0	0.0	7
	Quadmodal	2	100.0	0	0.0	0	0.0	0	0.0	2
Q3	Unimodal	146	50.9	85	29.6	22	7.7	34	11.8	287
	Bimodal	29	70.7	7	17.1	2	4.9	3	7.3	41
	Trimodal	16	88.9	2	11.1	0	0.0	0	0.0	18
	Quadmodal	1	100.0	0	0.0	0	0.0	0	0.0	1
Q4	Unimodal	147	51.0	83	28.8	21	7.3	37	12.8	288
	Bimodal	35	72.9	11	22.9	2	4.2	0	0.0	48
	Trimodal	8	100.0	0	0.0	0	0.0	0	0.0	8
	Quadmodal	2	66.7	0	0.0	1	33.3	0	0.0	3
Q5	Unimodal	139	50.5	81	29.5	22	8.0	33	12.0	275
	Bimodal	44	71.0	13	21.0	1	1.6	4	6.5	62
	Trimodal	5	83.3	0	0.0	1	16.7	0	0.0	6
	Quadmodal	4	100.0	0	0.0	0	0.0	0	0.0	4
Q6	Unimodal	129	49.6	77	29.6	22	8.5	32	12.3	260
	Bimodal	50	67.6	17	23.0	2	2.7	5	6.8	74
	Trimodal	11	100.0	0	0.0	0	0.0	0	0.0	11
	Quadmodal	2	100.0	0	0.0	0	0.0	0	0.0	2
Q7	Unimodal	127	49.2	75	29.1	22	8.5	34	13.2	258
	Bimodal	50	69.4	18	25.0	2	2.8	2	2.8	72
	Trimodal	7	77.8	1	11.1	0	0.0	1	11.1	9
	Quadmodal	8	100.0	0	0.0	0	0.0	0	0.0	8
Q8	Unimodal	119	47.8	76	30.5	20	8.0	34	13.7	249
	Bimodal	53	69.7	18	23.7	3	3.9	2	2.6	76
	Trimodal	16	88.9	0	0.0	1	5.6	1	5.6	18
	Quadmodal	4	100.0	0	0.0	0	0.0	0	0.0	4

(*Continued*)

Table 4 (Continued).

		College of Health Sciences		College of Engineering		College of Business		College of Law		Total
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	
Q9	Unimodal	119	48.4	72	29.3	21	8.5	34	13.8	246
	Bimodal	48	70.6	16	23.5	1	1.5	3	4.4	68
	Trimodal	20	74.1	6	22.2	1	3.7	0	0.0	27
	Quadmodal	5	83.3	0	0.0	1	16.7	0	0.0	6
Q10	Unimodal	117	47.4	75	30.4	20	8.1	35	14.2	247
	Bimodal	50	70.4	16	22.5	3	4.2	2	2.8	71
	Trimodal	14	87.5	2	12.5	0	0.0	0	0.0	16
	Quadmodal	11	84.6	1	7.7	1	7.7	0	0.0	13
Q11	Unimodal	110	48.5	63	27.8	21	9.3	33	14.5	227
	Bimodal	62	70.5	24	27.3	1	1.1	1	1.1	88
	Trimodal	15	57.7	6	23.1	2	7.7	3	11.5	26
	Quadmodal	5	83.3	1	16.7	0	0.0	0	0.0	6
Q12	Unimodal	128	48.9	76	29.0	22	8.4	36	13.7	262
	Bimodal	52	75.4	15	21.7	1	1.4	1	1.4	69
	Trimodal	6	66.7	3	33.3	0	0.0	0	0.0	9
	Quadmodal	6	85.7	0	0.0	1	14.3	0	0.0	7
Q13	Unimodal	112	47.9	69	29.5	19	8.1	34	14.5	234
	Bimodal	58	71.6	20	24.7	3	3.7	0	0.0	81
	Trimodal	15	65.2	4	17.4	1	4.3	3	13.0	23
	Quadmodal	7	77.8	1	11.1	1	11.1	0	0.0	9
Q14	Unimodal	143	50.5	83	29.3	21	7.4	36	12.7	283
	Bimodal	40	76.9	10	19.2	1	1.9	1	1.9	52
	Trimodal	5	71.4	1	14.3	1	14.3	0	0.0	7
	Quadmodal	4	80.0	0	0.0	1	20.0	0	0.0	5
Q15	Unimodal	122	49.8	71	29.0	18	7.3	34	13.9	245
	Bimodal	47	63.5	19	25.7	6	8.1	2	2.7	74
	Trimodal	19	79.2	4	16.7	0	0.0	1	4.2	24
	Quadmodal	4	100.0	0	0.0	0	0.0	0	0.0	4
Q16	Unimodal	109	46.6	68	29.1	22	9.4	35	15.0	234
	Bimodal	56	70.9	21	26.6	1	1.3	1	1.3	79
	Trimodal	19	79.2	4	16.7	0	0.0	1	4.2	24
	Quadmodal	8	80.0	1	10.0	1	10.0	0	0.0	10

Table 5 Tests for Normality for Selected Variables (CGPA & VARK SCORES)

	Kolmogorov–Smirnov[a]		Shapiro–Wilk	
	Statistic	Sig.	Statistic	Sig.
CGPA	0.103	0.000	0.883	0.000
V SCORE	0.185	0.000	0.916	0.000
A SCORE	0.139	0.000	0.958	0.000
R Score	0.128	0.000	0.949	0.000
K Score	0.377	0.000	0.684	0.000
Total VARK Score	0.116	0.000	0.975	0.000

Note: [a]Lilliefors Significance Correction.

VARK Score are 0.103, 0.185, 0.139, 0.128, 0.377, and 0.116, respectively, all with p-values of 0.000, indicating a rejection of normality. Similarly, the Shapiro–Wilk test statistics for these variables are 0.883, 0.916, 0.958, 0.949, 0.684, and 0.975, respectively, with p-values of 0.000, also rejecting normality. These tests are sensitive to sample size, and minor deviations can be significant in large samples. All variables show significant departures from normality, suggesting that parametric analyses assuming normality may not be appropriate. Researchers should consider non-parametric methods or data transformations for valid statistical inferences.

Table 6 presents the Mann–Whitney *U*-test results comparing unimodal and multimodal groups for variables such as V SCORE, A SCORE, R Score, K Score, Total VARK Score, Year of Study, and CGPA. Statistics include Mean Rank, Sum of Ranks, Mann–Whitney *U*, Wilcoxon *W*, *Z* statistic, and p-value for a two-tailed test. Except for CGPA, no

Table 6 Comparison of Quantitative Variables Based on Unimodal and Multimodal Learners

		Mean Rank	Sum of Ranks	Mann–Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
V SCORE	**Unimodal**	138.07	30512.50	5981.500	30512.500	−0.184	0.854
	Multimodal	140.25	7713.50				
A SCORE	**Unimodal**	140.23	30991.50	5694.500	7234.500	−0.731	0.465
	Multimodal	131.54	7234.50				
R Score	**Unimodal**	137.20	30,321.00	5790.000	30321.000	−0.552	0.581
	Multimodal	143.73	7905.00				
K Score	**Unimodal**	135.48	29941.00	5410.000	29941.000	−1.433	0.152
	Multimodal	150.64	8285.00				
Total VARK Score	**Unimodal**	139.12	30745.50	5940.500	7480.500	−0.260	0.795
	Multimodal	136.01	7480.50				
Year of Study	**Unimodal**	141.15	31195.00	5491.000	7031.000	−1.148	0.251
	Multimodal	127.84	7031.00				
CGPA	**Unimodal**	106.07	18243.50	3365.500	18243.500	−2.150	**0.032***
	Multimodal	128.32	6287.50				

Note: *CGPA showed a significant difference between the groups, with a Mann–Whitney U of 3365.500, a Z statistic of −2.150, and a p-value < 0.05, indicating that the unimodal group generally had lower CGPA ranks than the multimodal group.

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significant differences were found ($p > 0.05$) for V SCORE ($U = 5981.500$, $Z = -0.184$, $p = 0.854$), A SCORE ($U = 5694.500$, $Z = -0.731$, $p = 0.465$), R Score ($U = 5790.000$, $Z = -0.552$, $p = 0.581$), K Score ($U = 5410.000$, $Z = -1.433$, $p = 0.152$), Total VARK Score ($U = 5940.500$, $Z = -0.260$, $p = 0.795$), and Year of Study ($U = 5491.000$, $Z = -1.148$, $p = 0.251$). These results suggest similar distributions between groups, with differences likely due to chance. However, CGPA showed a significant difference ($U = 3365.500$, $Z = -2.150$, $p = 0.032$), indicating the unimodal group had generally lower CGPA ranks than the multimodal group. This suggests modality significantly impacts CGPA, which warrants attention from educators and researchers.

Table 7 compares academic performance indicators between male and female students, examining variables such as V SCORE, A SCORE, R Score, K Score, Total VARK Score, Year of Study, and CGPA. The table includes various statistical measures for each variable. While V SCORE, A SCORE, Year of Study, and CGPA show no significant gender disparities ($p > 0.05$). Notably, the Mann–Whitney *U*-test indicates significant gender differences in the R Score ($U = 4085.500$, $Z = -2.031$, $p = 0.042$), K Score ($U = 4187.000$, $Z = -2.150$, $p = 0.032$), and Total VARK Score ($U = 3911.500$, $Z = -2.329$, $p = 0.020$) with males outperforming females. These findings suggest comparable performance between male and female students in these areas. The outcomes highlight specific domains, such as R Score, K Score, and Total VARK Score, where gender-related variations in academic performance warrant further exploration and consideration by educators and researchers.

Table 8 presents a comparative analysis of academic performance metrics between the College of Health Sciences and other colleges, emphasizing V SCORE, A SCORE, R Score, K Score, Total VARK Score, Year of Study, and CGPA. Mann–Whitney *U*-tests reveal that students from the College of Health Sciences demonstrate lower scores in V SCORE ($U = 12{,}399.500$, $Z = -2.716$, $p = 0.007$), A SCORE ($U = 11{,}687.000$, $Z = -3.474$, $p = 0.001$), R Score ($U = 13{,}347.000$, $Z = -1.677$, $p = 0.094$), K Score ($U = 11{,}308.500$, $Z = -4.558$, $p < 0.001$), Total VARK Score ($U = 11{,}523.500$, $Z = -3.633$, $p < 0.001$), and CGPA ($U = 6268.500$, $Z = -4.281$, $p < 0.001$) compared to their counterparts in other colleges. However, Year of Study shows no significant difference between the two groups ($U = 13{,}686.500$, $Z = -1.332$, $p = 0.183$), suggesting comparable academic progression irrespective of college affiliation. These results highlight the necessity for targeted interventions to address the distinct academic needs of students within specific colleges and domains, promoting an environment that fosters academic success.

Table 7 Comparison of Quantitative Variables Based on Sex

		N	Mean (SD)	SEM	Mean Rank	Sum of Ranks	Mann–Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
V SCORE	**Male**	33	2.45(1.7)	0.29	182.62	6026.50	4896.500	54351.500	−0.528	0.598
	Female	314	2.32(1.8)	0.10	173.09	54351.50				
A SCORE	**Male**	33	4.45(2.4)	0.42	203.03	6700.00	4223.000	53678.000	−1.766	0.077
	Female	314	3.64(2.1)	0.12	170.95	53678.00				
R Score	**Male**	33	3.52(1.7)	0.30	207.20	6837.50	4085.500	53540.500	−2.031	**0.042***
	Female	314	2.89(1.7)	0.09	170.51	53540.50				
K Score	**Male**	33	1.24(0.5)	0.09	143.88	4748.00	4187.000	4748.000	−2.150	**0.032***
	Female	314	0.58(0.08)	0.05	177.17	55630.00				
Total VARK Score	**Male**	33	10.67(2.8)	0.48	212.47	7011.50	3911.500	53366.500	−2.329	**0.020***
	Female	314	9.44(2.8)	0.16	169.96	53366.50				
Year of Study	**Male**	33	2.48(1.1)	0.20	168.12	5548.00	4987.000	5548.000	−0.367	0.714
	Female	314	2.55(1.0)	0.05	174.62	54830.00				
CGPA	**Male**	29	3.19(0.6)	0.12	139.05	4032.50	3507.500	33642.500	−0.112	0.911
	Female	245	3.2(0.5)	0.03	137.32	33642.50				

Note: *Significant differences in learning style found in R score, K score, and Total VARK score at $p < 0.05$, with males outperforming females.

Table 8 Comparison of Quantitative Variables Based on Health Sciences Vs Other College Students

Health Sciences Vs Other Colleges		N	Mean (SD)	SEM	Mean Rank	Sum of Ranks	Mann–Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
V SCORE	**College of Health sciences**	192	2.09(0.1)	0.12	161.08	30927.50	12399.500	30927.500	−2.716	0.007
	All other colleges	155	2.64(0.15)	0.15	190.00	29450.50				
A SCORE	**College of Health sciences**	192	3.4(2.2)	0.16	157.37	30215.00	11687.000	30215.000	−3.474	0.001
	All other colleges	155	4.11(0.16)	0.16	194.60	30163.00				
R Score	**College of Health sciences**	192	2.83(0.12)	0.12	166.02	31875.00	13347.000	31875.000	−1.677	0.094
	All other colleges	155	3.11(0.14)	0.14	183.89	28503.00				
K Score	**College of Health sciences**	192	0.73(0.09)	0.06	192.60	36979.50	11308.500	23398.500	−4.558	**0.000***
	All other colleges	155	0.32(0.05)	0.05	150.96	23398.50				
Total VARK Score	**College of Health sciences**	192	9.05(2.9)	0.21	156.52	30051.50	11523.500	30051.500	−3.633	**0.000***
	All other colleges	155	10.17(2.6)	0.21	195.65	30,326.50				
Year of Study	**College of Health sciences**	192	2.61(1.1)	0.08	180.22	34601.50	13686.500	25776.500	−1.332	0.183
	All other colleges	155	2.47(0.97)	0.07	166.30	25776.50				
CGPA	**College of Health sciences**	164	3.31(0.47)	0.05	154.28	25301.50	6268.500	12373.500	−4.281	**0.000***
	All other colleges	110	3.11(0.47)	0.04	112.49	12373.50				

Note: *Significant differences found at p<0.05 in V, A, K, total VARK score, and CGPA, suggesting that health sciences students particularly excel in K, total VARK, and CGPA compared to other college students.

Table 9 compares students under 25 and over 26 across various preferred learning styles and their academic performance measures. Mann–Whitney *U*-tests and p-values indicate no significant differences in V SCORE and A SCORE ($p > 0.05$), suggesting similar performance in visual and auditory learning for both age groups. However, significant differences were found in the R Score ($Z = -2.992$, $p = 0.003$), K Score ($Z = -2.074$, $p = 0.038$), Total VARK score ($Z = -2.156$, $p = 0.031$), Year of Study ($Z = -2.657$, $p = 0.008$), and CGPA ($Z = -3.739$, $p < 0.001$). Negative

Table 9 Comparison of Quantitative Variables Based on Age Group

		N	Mean Rank	Sum of Ranks	Mann–Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
V SCORE	**Less than 25 years**	302	167.86	50695.00	4722.000	5250.000	−0.216	0.829
	More than 26 years	32	164.06	5250.00				
A SCORE	**Less than 25 years**	302	164.50	49678.50	3925.500	49678.500	−1.764	0.078
	More than 26 years	32	195.83	6266.50				
R Score	**Less than 25 years**	302	162.44	49056.00	3303.000	49056.000	−2.992	**0.003***
	More than 26 years	32	215.28	6889.00				

(*Continued*)

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Table 9 (Continued).

		N	Mean Rank	Sum of Ranks	Mann–Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
K Score	**Less than 25 years**	302	170.53	51499.50	3917.500	4445.500	−2.074	**0.038***
	More than 26 years	32	138.92	4445.50				
Total VARK Score	**Less than 25 years**	302	163.81	49471.50	3718.500	49471.500	−2.156	**0.031***
	More than 26 years	32	202.30	6473.50				
Year of Study	**Less than 25 years**	302	163.10	49255.50	3502.500	49255.500	−2.657	**0.008***
	More than 26 years	32	209.05	6689.50				
CGPA	**Less than 25 years**	232	125.21	29048.00	2020.000	29048.000	−3.739	**0.000***
	More than 26 years	30	180.17	5405.00				

Note: *Significant differences found at p<0.05 in R, K, total VARK score, year of study, and CGPA, suggesting that students less than 25 outperform their older counterparts.

Z values show that students under 25 have higher mean ranks in these areas, indicating they outperform older students in reading, kinesthetic learning, academic progression, and GPA. These results highlight the significance of age in academic performance, suggesting the need for age-specific educational interventions and support strategies.

Discussion

Learning is more easily embraced when it is presented in a manner that is appealing to students. The likelihood of achieving better exam results often increases when the learning experience is enjoyable. It is the responsibility of the teacher to understand their students' preferred learning styles and adapt accordingly, rather than expecting students to conform to their own teaching style.[25]

Understanding students' preferred learning styles and the factors that influence them is essential for teachers to improve their lesson plans and develop teaching methodologies that cater to their needs. This approach can also help break away from the traditional teacher-centered teaching model.[26] The current study conducted a cross-sectional analysis of 347 undergraduate students who had recently enrolled in their respective courses.

Preferred Modalities and Preferred Learning Styles

The results of the present study demonstrated that a preference for unimodal learning was observed across all colleges, ranging from 47.4% to 51.4% of respondents in the College of Health Sciences, which had the highest prevalence, to 11.8% to 15.0% in the College of Law, which had the lowest prevalence. While quadmodal learning preferences were least prevalent, they were occasionally observed and showed lower preferences in the Business and Law colleges compared to those in the Health Sciences and Engineering colleges. Unimodal learning preferences were more commonly observed in studies conducted in Malaysia[27] (86.8%), Iran[28] (42%), and Saudi Arabia[29] (53.8%). On the other hand, multimodal learning preferences were opted for in previous studies by 70% of the respondents in Saudi Arabia,[30] and 53.52% of the respondents in Nepal.[31]

In the current study, the auditory learning style is the most frequently chosen of all unimodal learning styles, with a mean score of 3.72 and a standard deviation of 2.181. Prior research has also indicated a preference for the auditory learning style, as 35.1% of participants in Saudi Arabia,[10] 4.09 mean and 0.68 SD in Riyadh, Saudi Arabia,[32] and 34% in India[33] preferred this style. However, a study conducted in India found that the kinesthetic learning style was the most preferred (49.2%),[25] and a study carried out in Iran found that the read/write learning style was the most favored (mean/SD 7.19/1.521).[26]

There are studies that show that, despite some effect, multimodal learning does not result in significantly higher grades than other learning styles.[34] Previous studies have found that teaching in health sciences is best aided by visual

stimulation: images, labeled diagrams, and cadaver teaching. In health sciences, researches have shown that students have benefitted from case-based learning (involving multimodal preferences) and this has been shown to improve understanding of concepts and academic performance.[7,35]

Learning Style Preferences and Age

The present study highlights the prevalence of Unimodal learning preferences across age groups. Bimodal learning preferences are significant, especially in the younger age group, and gradually decrease in the older age groups. Trimodal learning and quadmodal learning preferences, while less common, provide insights into the diversity of learning styles within each age group. The findings also suggest that students aged less than 25 years tend to have higher mean ranks and sum of ranks in R Score, K Score, Year of Study, and CGPA compared to their counterparts aged more than 26 years. The negative Z values (comparison of quantitative variables based on age) indicate that students aged less than 25 years generally outperform the older age group in these academic measures. In contrast to a study by Khanal et al,[31] which found more multimodal learners in both age groups, above and below 20 years, our study revealed that among the unimodal learners, the most preferred style was kinesthetic, followed by aural in both groups. Liew et al[36] also discovered that both age groups, above and below 20 years, were primarily kinesthetic learners. However, a higher proportion of those aged 20 years and above were multimodal learners (21%) compared to students aged <20 years (11.5%).

Learning Style Preferences and Gender

In the present study, female participants exhibit a slightly higher tendency towards bimodal and trimodal learning in certain scenarios than their male counterparts. Specifically, female participants are willing to engage with information using a combination of visual, auditory, read/write, and kinesthetic modalities. In contrast, both genders prefer singular learning modes, such as visual, auditory, read/write, or kinesthetic modalities. There is a limited preference for quadmodal learning that integrates diverse sensory modalities. However, previous studies by Pour et al[26] and Sarabi-Asiabar[37] have reported mixed results regarding the relationship between gender and learning styles, with one study observing a significant relationship between gender and single-modal learning styles in favor of male students.

Learning Style Preferences and Disciplines

The current study underscores the dominance of Unimodal learning preferences, with percentages ranging from 47.8% to 51.4% across disciplines. The College of Business exhibits lower Bimodal learning preferences compared to other colleges, with percentages ranging from 0.0% to 4.3%. In contrast, the College of Health Sciences and College of Engineering showed higher bimodal learning preferences, especially in scenarios where collaborative or diverse learning approaches may be beneficial. The College of Health Sciences and College of Engineering have slightly higher Quadmodal learning preferences than the College of Business and College of Law. Similar results were found in a study by Rezigalla and Ahmed (2019) where 118 students (86.8%) were unimodal in their learning preference, and 18 students (13.3%) were multimodal.[15] These preferences highlight instances in which students perceive the need for a fully immersive learning experience.

Learning Style and Academic Year

The study reveals a persistent reliance on Unimodal learning preferences throughout academic progression. Bimodal learning preferences, though variable, are consistently present across all years, reflecting a sustained interest in combining different learning modes. Trimodal and Quadmodal learning preferences, while less frequent, indicate a limited but existent interest in more diverse learning experiences. The outcomes of our research were aligned with previous findings by Rezigalla and Ahmed (2019), which revealed a unimodal pattern of learning style across all academic levels.[15] Among the unimodal style, the most prevalent learning style across academic levels was visual (4.8), followed by aural (3.8), R (2.8), and kinesthetic (2.3). The multimodal pattern was limited to level 1 generally (1.3). In another study, the unimodal learning style was favored by the majority of students in the 5th year (42.1%), while the quad-modal learning style was most preferred in the 2nd year (55.6%), with a declining trend in the advanced academic years.[30]

Learning Style Preferences and Academic Performances

In our research, we observed a minimal relationship between CGPA and other factors, except for a slight negative correlation with K Score ($r = 0.038$, $p < 0.01$). This suggests that kinesthetic learning preferences have a marginal effect on overall academic performance, highlighting the multifaceted nature of academic success. These results have practical implications for educators and administrators, stressing the need for tailored interventions and support mechanisms based on age. Recognizing the age-related variations in academic performance can help develop targeted strategies to address the unique challenges and needs of students in different age groups, thereby fostering an inclusive and effective learning environment. A study by Awang et al indicates that the highest domain of learning styles of students was kinesthetic, with the majority of students being kinesthetic learners across all CGPA categories.[38] Additionally, students with an aural learning style had higher average GPAs than others in Rezigalla and Ahmed's study.[15]

Study Strength

1. This study is the first to examine learning styles at the University of Buraimi. It offers insights into the differences in learning styles between health sciences students and students in other disciplines at UoB. This research aims to bring possible changes in teaching style.
2. A notable advantage of the VARK questionnaire is that it employs questions and options that are derived from genuine, everyday circumstances, allowing respondents to readily relate to the outcomes they obtain–this reinforces the instrument's face validity. VARK is dedicated to assisting students by recommending study strategies that can potentially enhance their learning experience.[39]
3. Teachers can effectively promote metacognition in their students by utilizing VARK. Encouraging students to learn about metacognition and the methods they can employ to monitor and manage their own learning, while also emphasizing the significance of reflection, goal-setting, and self-assessment, will enable students to take charge of their own learning and become proactive learners.[40]

Limitations

The study was limited by its cross-sectional design in one of the governorate's University in Oman, which prevented the establishment of causal relationships between variables on a larger scale. Furthermore, this study did not investigate the role of learners' motivation, learning environment, study skill, and learner's environment at their younger age. It is possible that educational background could have an impact on the learning style.

Recommendations

Further research is necessary to explore the potential relationship between learning style preferences, teaching and learning methods, and teaching styles. Considering the outcomes of this study, it is recommended that teaching methods be modified as necessary. To achieve this, a prospective cohort study spanning approximately four years, beginning at the onset of university education, should be conducted to track any changes in learning style as students' progress to higher levels. To improve student engagement and foster diverse learning approaches, we suggest introducing minor yet impactful modifications to existing teaching methods. For instance, incorporating interactive, real-time quizzes that students can access on their laptops or smartphones during lectures. Implementing these strategies at the conclusion of a lecture-based session has been demonstrated by Logan et al to improve students' concentration and enhance their retention of information.[41]

Conclusion

We conclude that our undergraduate students are diverse in their learning styles, although most of them were unimodal, other multimodal preferences were also observed. Notably, aural learners were found in the majority across various disciplines followed by read/write learners. The Colleges of Health Sciences and Engineering students exhibit marginally higher Quadmodal learning preferences than the Colleges of Business and Law, indicating a student perception of the necessity for fully immersive learning experiences. The findings of this survey can have practical implications for educators as they can develop targeted interventions to meet the unique needs of the learners. Teachers have a crucial role to play in recognizing the VARK learning preferences of their students, which can promote a greater appreciation for

learner diversity. By employing various teaching modalities, educators can create more interactive lessons. Nevertheless, it is essential to acknowledge that fully aligning teaching with individual VARK preferences can pose obstacles that may impede both instructors and students.

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Disclosure

The authors report no conflicts of interest in this work.

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