Journal of the Anatomical Society of India 67 (2018) 186–192

Contents lists available at ScienceDirect

Journal of the Anatomical Society of India

journal homepage: www.elsevier.com/locate/jasi

Original Article

Off-line virtual microscopy in teaching histology to the undergraduate medical students: do the benefits correlate with the learning style preferences?

Mamata Chimmalgi

Department of Anatomy, Sree Gokulam Medical College & Research Foundation, Venjaramoodu, Trivandrum, 695607, Kerala, India

ARTICLE INFO

Article history:
Received 7 January 2018
Accepted 6 November 2018
Available online 14 November 2018

Keywords:
Conventional microscopy (CM)
Virtual microscopy (VM)
Learning style preferences (LSP)
VARK questionnaire

ABSTRACT

Introduction: Advances in technology have metamorphosed the methods and tools used in medical education. Teaching microscopic anatomy has shifted in the last few decades from conventional microscopy using light microscope and glass slides to virtual microscopy using computers and virtual slides.

Students differ in their learning style preferences. Their performance is optimized when the teaching method or a strategy is adopted to their learning style preference.

The purpose of this study was to determine the impact of using the off-line virtual slides in teaching histology on the performance of the first-year medical students and to ascertain its suitability to students with different learning style preferences.

Method: Learning style preferences of the students was determined by using VARK questionnaire. Students were taught histology using the offline virtual slides. Pre- and post-intervention tests using two methods of examination determined the impact of virtual slides in teaching anatomy to students with different learning style preferences.

Results: Using paired *t*-test, independent *t*-test and Kruskall Wallis rank test (as applicable), intra- and inter-group scores for the pre- and post-tests were compared. Results revealed significant gain in the scores with the use of virtual slides irrespective of the method of examination or learning style preferences.

Discussion: Virtual slides, when used in teaching histology as an adjunct to conventional microscopy, positively influenced the performance of the students irrespective of their learning style preferences. Offline virtual slides can be a via-media approach for using virtual microscopy in the institutions lacking in high-end infrastructure.

1. Introduction

Advances in technology have revolutionized the methods and tools used in medical education; Virtual Microscopy (VM) being the recent testimony to the statement. Although Conventional Microscopy (CM), using glass slides and optical microscopes, has been the standard method of histology instruction for over a century, it (a) limits the students' access to slides to the scheduled time; (b) requires constant replacement of slides, equipment and supplies; (c) demands space for both the laboratory facilities and archiving; (d) affects learning due to variability of slides and (e) becomes less effective with higher student-faculty ratio. Virtual microscopy (VM) is a technology where the glass slides are at first digitized using sophisticated scanner at high resolution; multiple large image files are tiled together using a software and stored in a compressed file format on a computer server. Through internet or intranet, unlimited viewers can then access and view these high-quality, standardized, zoom-able, life-like images of virtual slides on their computer screen with the help of a viewer software.[1] VM lends itself to easy archiving, quantitative image analysis, sharing the slides through a database, and telepathology.[1,2] Virtual slides are easy to store, duplicate, annotate, manage, and do not deteriorate easily, making them cost-effective in the long term.[3] Learning with VM is not adversely influenced by limitations of time, personnel, teaching material, class size or skill in using microscope. These compelling advantages have persuaded many medical schools to adopt VM either exclusively or with a blended approach. Studies have been conducted to establish the merits of using VM in teaching histology or pathology to medical,[3–10] dental,[11,12]

E-mail address: mamatachimmalgi@gmail.com (M. Chimmalgi).

https://doi.org/10.1016/j.jasi.2018.11.010
0003-2778/

chiropractic[13] and veterinary[14] students across the world. Students accessed the virtual slides through internet,[3,7] intranet[6,10] or offline CD-ROMs,[5,11] either individually or in groups. [3,8,15]

Every individual has a unique 'learning style' that is remarkably resistant to change [13,16]. The term 'learning style' encompasses a broad concept in the literature, defined by Keefe as 'composite of characteristic cognitive, affective and physiological characters that serve as relatively stable indicators of how a learner perceives, interacts with and responds to the learning environment'.[17] It is the way the learners most efficiently perceive, assimilate and recall what they attempt to learn.[18] One of the many characteristics that make up student's 'learning style' is the sensory modality by which the students 'prefer' to take in new information.[19] To determine these 'learning style preferences' (LSP) Fleming has designed VARK survey tool that defines four sensory modalities, namely, Visual, Auditory, Read/write and Kinesthetic (acronym VARK).[20] Visual learners prefer graphical or pictorial representations as the means of new information. Auditory learners prefer lectures, discussions, etc. Read/write learners prefer textual format while Kinesthetic learners prefer experiential learning using photographs, exhibits, simulations, role-plays, etc. While some learners prefer a single sensory modality, others may prefer a combination of two or more (multimodal). Individual's LSP determines how a student responds to different teaching strategies. Students' motivation and performance are found to be optimum only when the method of instruction is matched to their LSP.[16,17] Hence, when experimenting with a new method of instruction, educators must choose judiciously to cater to the mixed LSP of a group of students.

The purpose of this study was to (a)determine the impact of teaching histology using off-line virtual slides on the performance of the first-year medical students and (b)determine if the use of virtual slides selectively benefitted the students with specific learning style preferences.

2. Method

2.1. Design and sample

An experimental study was conducted after obtaining permission from the Institutional Ethics Committee, with a single group, pre- and post-intervention design, using convenience sampling within the cohort of first-year medical students. Student participation was voluntary following informed consent.

2.2. Preparation

To offset the lack of high-speed internet facility in the lecture halls and practical Laboratory, Dr. Michael Hortsch at the University of Michigan Medical School was consulted to explore the possibilities of procuring the virtual slides with *offline access*.[7] Owing to his immediate affirmative action, all the histology virtual slides (some files of more than 1 GB size) were made available in 1TB hard disc.

To identify the students' LSP, Neil D. Fleming, designer of VARK questionnaire & Director of VARK LEARN Limited was contacted. Individual Teacher Subscription was obtained for the use of VARK Questionnaire by 150 first-year medical students. VARK Learn Limited provided URL links for two webpages – a participants' webpage for the students to complete the questionnaire and a password-protected administrator's webpage for the results of the survey.

2.3. Procedure

Students were given the URL link for the participants' webpage to access the VARK Questionnaire and answer as per the instructions on the site.

Over the first 8 weeks, twenty histology slides were taught using traditional method of didactic lecture followed by practical session. In the practical sessions, students were required to study the glass slides under the optical microscope with the help of instructors. Each practical session covered 2–3 slides of variable difficulty level.

Over the next eight weeks, a different set of twenty slides, of varying difficulty levels were taught; this time with one major difference of additional demonstration of virtual slides with the help of Aperio ImageScope software. Didactic lectures and practical sessions were unchanged, but, the students were demonstrated the virtual slides using an interactive session. Two stand-out advantages of this interactive session were: zoom-able, high-quality, virtual slides made it convenient to demonstrate all the relevant features uniformly to all the students and active participation of the students made them 'slide-ready' prior to the practical sessions.

2.4. Data collection

Results of the VARK Questionnaire survey were obtained from the password-protected administrator's webpage.

At the end of each eight-weeks' session, two examinations were conducted: a traditional steeple-chase method of examination, where the students were required to identify the slides under the microscope and answer the relevant questions and a second method of examination using the virtual slides projected on the screen for the same histology topics, requiring the students to identify the slide or a marked detail and answer the relevant questions. In both the methods, time allotted was 1 min per slide. Each test was scored for a maximum score of twenty. Examination conducted after the first eight-weeks were the pre-tests, labelled as 'A1' for the steeple-chase method & 'E1' for the examination using the virtual slides. Examinations conducted after the next eight-weeks of teaching with the virtual slides were the post-tests, and were labelled as 'A2' for the steeple-chase method and 'E2' for the examination using the virtual slides.

2.5. Data analysis

VARK results were analyzed for uni- and multi-modal preferences. Intra- and inter-group average scores for the pre- and post-tests for both the methods of examinations were compared using paired *t*-test, independent *t*-test or Kruskall Wallis rank test (as applicable).

3. Results

Among the 150 first-year medical students who had consented for participating in the study, only 87 (20 boys and 67 girls in the age group of 18–21 years) completed VARK questionnaire, as well as, all the four tests (A1, A2, E1 & E2) and only these students were included as study participants.

3.1. Learning style preferences as assessed by VARK

Number of students with multimodal LSP exceeded the number of students with unimodal LSP (Fig. 1). Distribution of students with unimodal (V, A, R or K), bi-modal (VA, VR, VK, AR, AK or RK), tri-modal (VAR, VAK, VRK or ARK) or quad-modal (VARK) learning preferences is shown in Fig. 2. Girls preferred unimodal LSP whereas boys preferred quad-modal. Tri-modal preference was the least common. Fig. 3 shows the percentage of students with Visual, Auditory, Read/write & Kinesthetic LSP. Girls preferred the kinesthetic mode while the boys, the auditory mode. Detailed LSP of the whole group and for the sub-groups of boys and girls are shown in Fig. 4. Quad-modal (VARK) learning preference was the

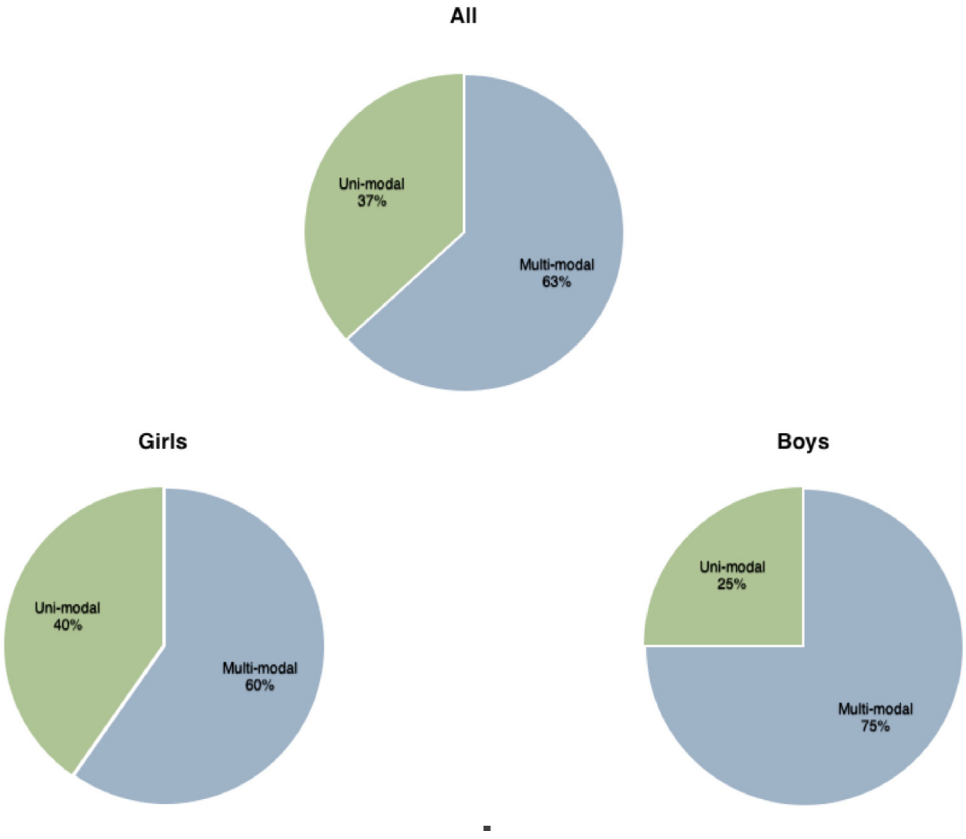

Fig. 1. Percentage of students with Multimodal and Unimodal Learning Style Preferences.

Fig. 2. Percentage of students with Unimodal, Bi-modal, Tri-modal and Quad-modal Learning Style Preferences.

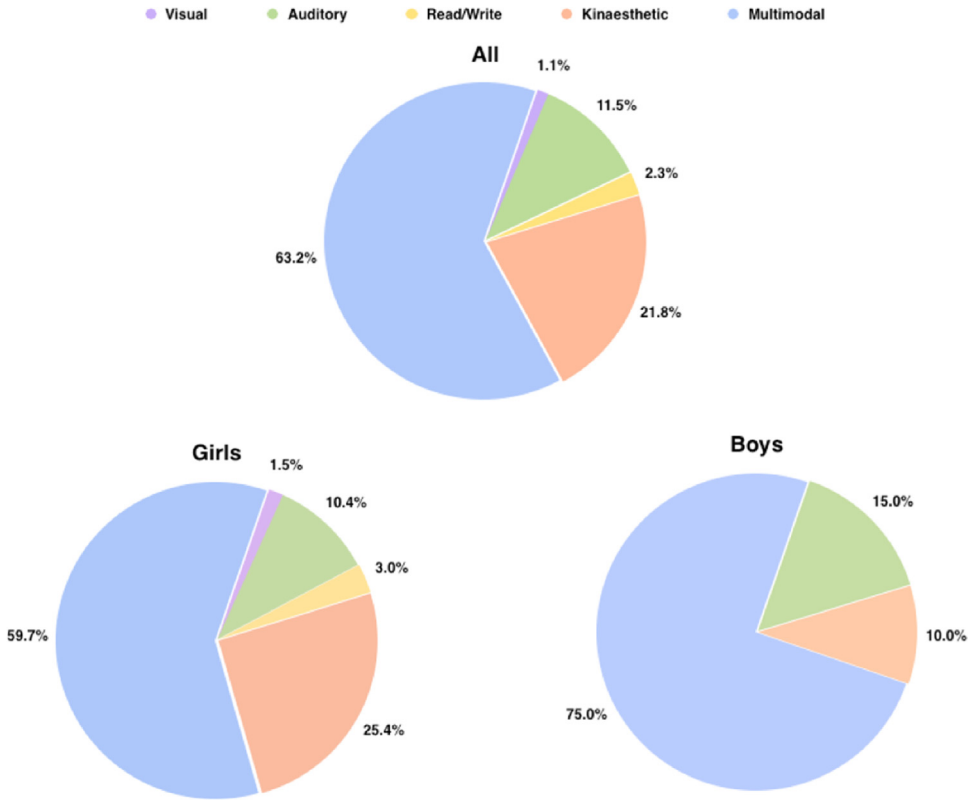

Fig. 3. Percentage of students with Visual, Auditory, Read/Write, Kinaesthetic and Multi-modal Learning Style Preferences.

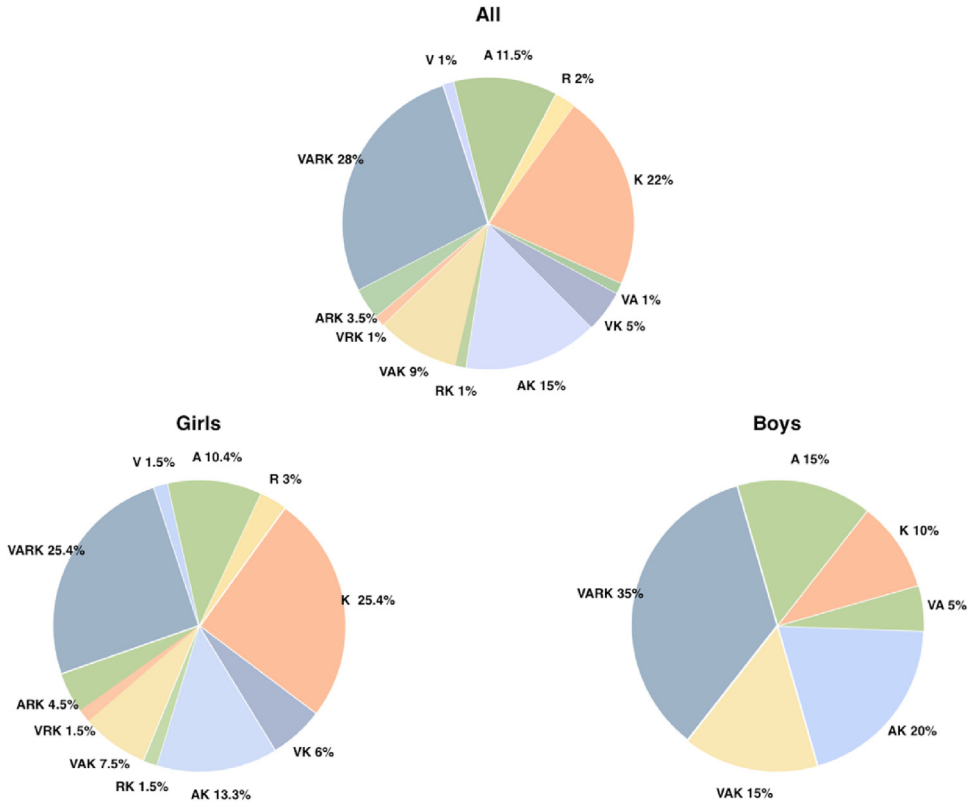

Fig. 4. Percentage of students showing detailed different Learning Style Preferences.

commonest in all the three cases. Boys were segregated into fewer modes of LSP as compared to the girls.

3.2. Student performance

a When pre- and post-test average scores for both the methods of examination were compared (A1 with A2 and E1 with E2), significant difference was found between the two for the whole group of students, among the students with multimodal LSP and among the students with unimodal LSP (Table 1).
b When the two methods of examination were compared, scores with the traditional steeple-chase method were found to be significantly higher than those for the examination using virtual slides in both the pre-and the post-tests (Table 2). However, the gain in the score between the pre- & post-tests for the examination using virtual slides was significantly higher than the gain with the traditional steeple-chase method (Table 3).
c Average scores in pre- and post-tests for both the methods of examination for the students with different LSP are shown in Table 4. Post-tests scores were higher irrespective of the method of examination.
d There was no gender bias in the performance when scores of boys and girls in pre- and post-tests for either method of examination were compared (Table 5).
e There was no significant difference between the performance of the students with multimodal LSP and unimodal LSP for either method of examination (Table 6).
f To test the hypothesis that, the virtual slides, being life-like images, are more likely to benefit the students with visual, kinesthetic or both (V, K and VK) learning preferences, the test performance of these students was compared with the rest of the students. Results showed that there was no significant difference between the performance of the two groups for either method of examination (Table 7).
g To test the hypothesis that, the virtual slides, being life-like images, are least likely to benefit the students with Auditory, Read/write or both preferences (A, R and AR), the test performance of these students was compared with the rest of the students. While there was no significant difference in the performance of the two groups with steeple-chase method examination, there was a borderline significant difference for the test using virtual slides (Table 8).
h Using Kruskal Wallis rank test, performance of the students of visual or kinesthetic or both LSP (V, K and VK; n = 24) was compared with the students of auditory or read /write or both LSP (A, R and AR; n = 12) and with the remaining students of other multimodal LSP (n = 51). There was no significant difference between the performance of the three groups either for the examination using the steeple-chase method (p-value = 0.355) or the virtual slides (p-value = 0.120).
i Using Kruskal Wallis rank test, performance of the students with visual LSP (n = 1) was compared with the performance of students with Auditory (n = 10), Read/write (n = 2), Kinesthetic (n = 19) and Multimodal (n = 55) LSP (V, A, R, K and MM). There was no significant difference between the performance of these five groups either for the examination using the traditional steeple-case method (p-value = 0.630) or the virtual slides (p-value = 0.387).
j For 150 students, the time required for conducting the examination using the virtual slides was approximately 25 min (including instructions) whereas for the traditional steeple-chase method, it was approximately 200 min.

Table 1
Comparison of the Average Scores in Pre- and Post-Tests Using Paired *t*-test.

Test	Mean	Standard deviation	t value	p-value	Remark
Whole group (n = 87)					
A1	15.78	3.402	4.680	< 0.001	Highly significant
A2	17.1034	2.5337			
E1	6.91	2.832	11.854	< 0.001	Highly significant
E2	11.003	3.3605			
Students with Multimodal Learning Preferences (n = 55)					
A1	15.49	3.551	3.338	0.002	Significant
A2	16.713	2.708			
E1	6.59	2.735	9.581	< 0.001	Highly significant
E2	10.495	3.293			
Students with Unimodal Learning Preferences (n = 32)					
A1	16.27	3.121	3.346	0.002	Significant
A2	17.773	2.073			
E1	7.46	2.952	7.011	< 0.001	Highly significant
E2	11.875	3.346			

4. Discussion

This study assessed the effectiveness of using the offline virtual slides as a supplementary teaching tool in teaching histology to the first-year medical students and whether it selectively benefitted the students with certain LSP.

The use of light microscopes and glass slides in teaching histology and pathology has transitioned into the use of computers and virtual slides due to the advances in technology. VM facilitates telepathology that finds its use not only in e-education but also in patient care at a lesser cost.[2,4,21] Virtual slides can be accessed anywhere and at any time, making them an ideal tool for instructor-based teaching, interactive sessions with Socratic approach, self-directed learning, reciprocal peer teaching, small group discussions, continued medical education, interdisciplinary problem-based learning, assessments and certifying exams.[10,14,22] Many recommend a complete switch to VM due to improved student performance, reduced student-contact time, ease of maintenance and long-term cost-effectiveness.[5,11,23,24] Others advocate the use of VM as a supplement to CM, emphasizing on introducing the students to the use of microscope and to the concept of preparing the slides.[4,6,8,12,25] In an online survey conducted, of the 45 respondents, 13 reported that their laboratory used microscopes, 20 reported the use of VM and 12 reported the use of both.[26] In the present set-up, a complete switch to VM might not be practical as the pattern of summative assessment mandates the use of CM. However, the advantages of VM make a compelling argument for its use as an adjunct to CM. The interactive format in which the virtual slides were included for teaching histology in the current study did not demand excessively on technical infrastructure or scheduling and hence, was easy to adopt.

Results of this study showed that, the use of offline virtual slides as an adjunct to CM improved the performance of the students in the post-tests irrespective of the method of examination (Table 1). Scores were higher for the steeple-chase method of examination than for the method using the virtual slides (Table 2), possibly due to greater proficiency in the former method and inclusion of questions addressing higher Bloom's cognitive levels in the latter method. This contrasts with the findings of other studies, where the performance was similar for both the methods of examination[8,9,22] or was better for the method using the virtual slides[4] or was unaffected by either method of learning when an unbiased third method of assessment was used.[27] Gain in the score between the pre- and post-tests was greater for the method using the virtual slides than for the steeple-chase method (Table 3). The time required for steeple-chase method of examination far exceeded the time required for the examination using the virtual slides and the findings of this study are in concurrence with the other studies.[4]

Students differ in their learning preferences; their attitude and performance being more positive when a method of instruction is adapted to their learning preferences. Educators often choose a method of teaching based on the philosophy of the program,

Table 2
Comparison of the Average Scores of the Two Methods of examination Using Paired *t*-test.

Test	Mean	Standard deviation	t value	p-value	Remark
Comparison between the average scores of the pre-tests using both the methods of examination (n = 87)					
A1	15.78	3.402	24.984	< 0.001	Highly Significant
E1	6.91	2.832			
Comparison between the average scores of the post-tests using both the methods of examination (n = 87)					
A2	17.103	2.533	15.786	< 0.001	Highly Significant
E2	11.003	3.360			

Table 3
Comparison of the Difference in the Average Scores of Pre- & Post- tests Using the Two Methods of examination by Paired *t*-test.

Method	Mean Score Difference between Pre- & Post-tests	Standard deviation	t value	p-value	Remark
Steeple-chase method	1.325	2.640	6.235	< 0.001	Highly Significant
Virtual Slides method	4.095	3.222			

Table 4
Average Scores of Students with Different Learning Preference in pre- & Post-Tests.

Learning Preference	n	Average score in A1	Average score in A2	Average score in E1	Average score in E2
Multimodal (VARK)	24	16.19	17.44	6.77	11.03
Multimodal (VAK)	8	14.78	14.56	6.59	9.68
Multimodal (VRK)	1	12	12	5.25	8.75
Multimodal (ARK)	3	15	16.66	7	8
Multimodal (VA)	1	4	15.5	3.5	6.25
Multimodal (VK)	4	16.56	18.06	8.31	11.5
Multimodal (AK)	13	15.21	16.63	6.07	10.76
Multimodal (RK)	1	20	18	5	10
Unimodal (Visual)	1	16	16	9.5	12.5
Unimodal (Auditory)	10	15.57	17.92	7	12.82
Unimodal (Read/write)	2	14.75	17	4.25	9.87
Unimodal (Kinesthetic)	19	16.81	17.86	7.93	11.55

Table 5
Results of Independent *t*-test to Compare the Performance of the Girls with the Boys.

Method of Examination	Group	n	Mean Score Difference between Pre- & Post-tests	Standard Deviation	t	p-value	Remark
Steeple-chase	Girls	67	1.0037	2.256	1.680	0.106	Not significant
	Boys	20	2.400	3.506			
Virtual Slides	Girls	67	4.108	3.428	0.070	0.944	Not significant
	Boys	20	4.05	2.479			

Table 6
Results of Independent *t*-test Comparing the Performance of the Students with Multimodal Learning Preference (MLSP) and Unimodal Learning Preference (ULSP).

Method of Examination	Group	n	Mean Score Difference between Pre- & Post-tests	Standard Deviation	t	p-value	Remark
Steeple-chase	MLSP	55	1.227	2.716	0.470	0.639	Not significant
	ULSP	32	1.500	2.536			
Virtual Slides	MLSP	55	3.909	3.026	0.703	0.484	Not significant
	ULSP	32	4.414	3.561			

Table 7
Results of Independent *t*-test to Compare the Performance of the Students with Visual or Kinesthetic or Both Learning Preference (V&K) and Others.

Method of Examination	Group	n	Mean Score Difference between the Pre- & Post-tests	Standard Deviation	t	p-value	Remarks
Steeple-Chase	V, K & VK	24	1.083	2.296	0.524	0.602	Not significant
	Others	63	1.417	2.771			
Virtual Slides	V, K & VK	24	3.521	3.585	1.026	0.308	Not significant
	Others	63	4.313	3.075			

Table 8
Results of Independent *t*-test to Compare the Performance of the Students with Auditory or Read/write or Both Learning Preference (A&R) and Others.

Method of Examination	Group	n	Mean Score Difference between the Pre- & Post-tests	Standard Deviation	t	p-value	Remarks
Steeple-Chase	A, R & AR	12	2.333	2.953	1.434	0.155	Not significant
	Others	75	1.163	2.572			
Virtual Slides	A, R & AR	12	5.792	2.775	1.999	0.049	Borderline significant
	Others	75	3.823	3.221			

course content, available infrastructure, nature of an individual topic that yields itself to a certain method, personal preference, ease or novelty of the method. [28] However, when a new education tool or strategy is being experimented with, it behooves to assess its suitability to students with different LSP. In the current study, LSP of the participants was identified by using the VARK Questionnaire survey. Study results revealed that the students' performance in the tests was neither influenced by the gender nor by their LSP. Irrespective of the LSP and the methods of examination, students scored better in the post-tests (Table 4), validating the use of virtual slides as a teaching tool. Although life-like images of the slides were displayed on the screen using a method closely simulating visualization under the microscope at various magnifications, the method neither selectively benefitted the visual or the kinesthetic learners nor adversely influenced the auditory and the read/write learners (Tables 7 & 8 ; Kruskall Wallis Rank Test results). In this study, knowledge about the learners' LSP facilitated adopting a multi-sensory presentation of the virtual slides through an active learning strategy.[17,18,19] This, in turn, might have enabled the learners with differing LSP to easily adopt to the virtual slides affirming the VARK philosophy that everyone can learn if their preferences are addressed. [29]

5. Conclusion

In conclusion, teaching histology using the virtual slides as an adjunct to CM is beneficial to the students irrespective of their learning style preferences, especially when introduced using an active teaching strategy. Using offline version of virtual slides can be a via-media approach for those institutions lacking in availability of high-speed internet facility at the areas of instruction.

Grants received

None

Acknowledgements

Author is indebted to Dr. Michael Hortsch, Associate Professor in the Department of Cell & Developmental Biology at the University of Michigan Medical School, Ann Arbor, Michigan for providing the offline virtual slides.

Author is extremely grateful to Neil D. Fleming, Designer of VARK questionnaire & Director of VARK LEARN Limited for permitting the use of VARK Questionnaire (VARK Questionnaire© Copyright Version 7.8 (2016) held by VARK Learn Limited, Christchurch, New Zealand).

Author expresses heartfelt thanks to Mrs. Manju L, Assistant Professor (Statistics) for her contribution to statistical analysis.

Author wishes to express gratitude to her colleagues in the department for helping in introducing the virtual slides to the students and the first MBBS students for their enthusiastic participation.

References

1. Hortsch M. Sharing virtual histology images worldwide: The virtual microscopy database. *J Cytol Histol.* 2017;8(5):e12010.4172/2157-7099.1000e120.
2. Coleman R. The advantages of virtual microscopy for teaching histology. *Ital J Anat Embryol.* 2013;118(2):58.
3. Bloodgood R. Active learning: A small group histology laboratory exercise in a whole class setting utilizing virtual slides and peer education. *Anat Sci Educ.* 2012;5:367–37310.1002/ase.1294.
4. Anyanwu GE, Agu AU, Anyaeheie UB. Enhancing learning objectives by use of simple virtual microscopic slides in cellular physiology and histology: Impact and attitudes. *Adv Physiol Edu.* 2012;36(2):158–16110.1152/advan.00008.2012.
5. Blake CA, Lavoie HA, Millette CF. Teaching medical histology at the University of South Carolina School of Medicine: Transition to virtual slides and virtual microscopes. *Anat Rec (Part B: New Anat).* 2003;(275B):196–20610.1002/ar.b.10037.
6. Harris T, Leaven T, Heidger P, Kreiter C, Duncan J, Dick F. Comparison of virtual microscope laboratory to a regular microscope laboratory for teaching histology. *Anat Rec.* 2001;265(1):10–1410.1002/ar.1036.
7. Hortsch M. From microscopes to virtual reality – How our teaching of histology is changing. *J Cytol Histol.* 2013;4:e10810.4172/2157-7099.1000e108.
8. Kumar RK, Velan GM, Korell SO, Kandara M, Dee FR, Wakefield D. Virtual microscopy for learning and assessment in pathology. *J Pathol.* 2004;204:613–61810.1002/path.1658.
9. Scoville SA, Buskirk TD. Traditional and virtual microscopy compared experimentally in a classroom setting. *Clin Anat.* 2007;20(5):565–57010.1002/ca.20440.
10. Pospisilova E, Cernochova D, Lichnovska R, Erdosova B, Krajci D. Application and evaluation of teaching practical histology with the use of virtual microscopy. *Diagn Pathol.* 2013;8(1):S710.1186/1746-1596-8-S1-S7.
11. Alotaibi O, AlQahtani D. Measuring dental students' preference: A comparison of light microscopy and virtual microscopy as teaching tools in oral histology and pathology. *Saudi Dent J.* 2016;28:169–17310.1016/j.sdentj.2015.11.002.
12. Felipe-Paiva F, Santos-Silva A, Lopes M, de Almeida O, Vargas P. Transition from glass to digital slide microscopy in the teaching of oral pathology in a Brazilian dental school. *Med Oral Pathol Oral Cir Bucal.* 2015;20(1):e17–e2210.4317/medoral.19863.
13. Jonas-Dwyer D, Sudweeks F. Informing students using virtual microscopes and their impact on students' approach to learning. *Info Sci J.* 2007;10:61–70.
14. Dee FR, Meyerholz DK. Teaching medical pathology in the twenty-first century: Virtual microscopy applications. *J Vet Med Edu.* 2007;34(4):431–43610.3138/jvme.34.4.431.
15. Goldberg HR, Dintzis R. The positive impact of team-based virtual microscopy on student learning in physiology and histology. *Adv Physiol Edu.* 2007;31(3):261–26510.1152/advan.00125.2006.
16. Dunn R, Beaudry JS, Klavas A. Survey of research on learning styles. *Edu Leadership.* 1989;46(6):50–58.
17. Baykan Z, Nacar M. Learning styles of first-year medical students attending Erciyes University in Kayseri, Turkey. *Adv Physiol Educ.* 2007;31:158–16010.1152/advan.00043.2006.
18. Lujan LH, DiCarlo SE. First year medical students prefer multiple learning styles. *Adv Physiol Educ.* 2006;30:13–1610.1152/advan.00045.2005.
19. Slater JA, Lujan LH, DiCarlo SE. Does gender influence learning style preferences of first year medical students. *Adv Physiol Educ.* 2007;31:336–34210.1152/advan.00010.2007.
20. Fleming ND. VARK: A guide to learning styles. With a VARK individual subscription link http://site.vark-learn.com/?access=chimmalgi.
21. Ayad E, Yaagi Y. Virtual Microscopy beyond the Pyramids, application of WSI in Cairo University for e-education and telepathology. *Anat Cell Pathol (Amst).* 2012;35(2):93–9510.3233/ACP-2011-0027.
22. Heidger [84_TD$DIFF]Jr PJr, Dee F, Consoer D, Leaven T, Duncan J, Kreiter C. Integrated approach to teaching and testing in histology with real and virtual imaging. *Anat Rec.* 2002;269(2)107–112 https://doi.org/10/1002/ar.10078.
23. Krippendorf BB, Lough J. Complete and rapid switch from light microscopy to visual microscopy for teaching histology. *Anat Rec(Part B: New Anat).* 2005;285B(1):19–2510.1002/ar.b.20066.
24. Ordi O, Bombi JA, Martinez A, et al. Virtual microscopy in the undergraduate teaching of pathology. *J Pathol Inform.* 2015;6:110.4103/2153-3539.150246.
25. Munoz AL, Lopez JL. Use of virtual microscopy to promote histology learning. In: A Mendez-Vilas A, ed. *Microscopy: advances in scientific research and education.* :1210–1213.
26. Drake RL, McBride JM, Lachman N, Pawlina W. Medical education in the anatomical sciences: The winds of change continue to blow. *Anat Sci Educ.* 2009;2(6)10.1002/ase.117 259-259.
27. Mione S, Valcke M, Cornelissen M. Evaluation of virtual microscopy in medical histology teaching. *Anat Sci Edu.* 2013;6(5):307–31510.1002/ase.1353.
28. Alkhasawneh IM, Mrayyan MT, Docherty C, Alashram S, Yousef HY. Problem-based learning (PBL): Assessing students' learning preferences using VARK. *Nurse Educ Today.* 2008;28:572–57910.1016/l.nedt.2007.09.012.
29. Wehrwein EA, Lujan LH, DiCarlo SE. Gender differences in learning style preferences among undergraduate physiology students. *Adv Physiol Educ.* 2007;31:153–15710.1152/advan.00060.2006.