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The Effect of Contexts on Learning Styles in M-Learning Environment using Chi Square Test

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Abstract*: The mobile learning system is the anywhere anytime learning that can happen with the smart devices with network connectivity. The learner is the one who learns through these portable smart devices in a personalized environment. So the M-Learning system should understand the needs of a learner, the learning styles and features of the devices; and accordingly should build the context of the learner. The system should adapt itself to the context of the learner, to deliver the content in the video or audio or text formats. The learning styles are identified as V for Visual, A for auditory, R for read and K for kinesthetic. In this paper two contexts – college and house has been considered for the study of Chi Square Test. The Chi Square test has been conducted to find the association and dependencies between the various categorical variables of college and house against the VARK learning styles.

Keywords: VARK, M-Learning, the Chi Square Test, Context, Personalization, Adaptive Learning.

I. INTRODUCTION

The M-Learning system should be adaptive to the needs of different learners; who has different individual mobile learning preferences. Study of these m-learning preferences can be used as a basis for creating personalized learning platforms catered to the needs of individual learners. Learning styles are the major factors that impact on the m-learning. Learners have different styles, preferences of learning and aids which help them to learn effectively. "Meta-cognition" means to understand how a learner, as an individual, learns to the best. A learning style defines the way that a learner prefers to learn; learner prefers certain strategies ways i.e. like getting information in a specific way. Thinking, feeling or behaving of learners can influence the learning styles. The learner factors can be influenced by personalization, the context of a learner. The 2 important factors are: (i) Learner analysis (ii) Context analysis.

A. Learner Analysis

Learner analysis includes analysis of learning behavior, styles, type of learning and brain dominance. Each learner carries different characteristics of each of them. Qualities of the learners impact learning objectives and effect the way wherein learning happens. Understanding and taking into contemplation the attributes of the students can decide if the learning knowledge is important. Creating instruction that suits to every type of learning style for learners is not easily possible. Understanding the various learners learning styles can provide alternatives. Types of learning styles of learners listed below in Table I.

Table -I: Various Learning Styles

Style	Description
Visual/Perceptual (V) .	Learners prefer looking. Demonstrations, for example, charts, writing on blackboard, diagrams, and graphs. pictures, flowcharts, timelines, videos, and demonstrations .
Auditory (A)	Learners prefer information presented in an oral way. Example classroom; listening to lectures; participating in group discussions.
Read (R)	Learners prefer to read/go through the text content
Tactile/Kinesthetic (K)	Learners prefer physical engagement i.e. "Hands on" activity. Prefer performing/doing practices rather just reading.

B. Context Analysis

In addition to learner analysis, context analysis should also be focused. For, understanding the context; new skills, knowledge, attitude, behavior, surroundings -will be used in the planning of instructional activities that will estimate what learners will face in the real scenario. Understanding the learning context helps to identify difficulties in the setting and best use the instructional learning environment. It involves describing the nature of the learning context and compatibility and constraints of the environment for the learners and instructional goals.

II. PROPOSED WORK

For this study a programming subject for the first year engineering students has been taken into consideration. We have captured learning preferences of "C Programming" for individual students; 514 students of various branches of engineering are participated in this analysis. Table II provides the details of students of various branch of engineering.

Table II: Number of Students Participated

Branch	No. of students
Computer Science / Information Science	210

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Master of Computer Science	7
Mechanical	5
Civil	0
Electronics	2
Electrical	60

The Table III will give details about the characteristics that are being assumed for our circumstances and assumptions.

Table III: Context Characteristics and Possible Values

Characteristics (Variables)	Possible Values
Gender	Male, Female
Place	House – Room , Hall, Gallery
	College – Classroom , Library, Campus
Time	Morning , Afternoon , Evening , Night
Smart device	Smart phone, iPad, Tab
Content Formats	➢ Animations/ Illustrations/ Videos with demos ➢ Listen to Lecture Videos/ Discussions ➢ Reading Text/ Reading PDF/ Reading Notes/ Taking Notes/Reading from notes ➢ Practices/ Do Rough Work/ Mind Map (short notes in diagrammatic approach)

These factors help to identify the context of a student. Fig. 1 depicts an example of context scenario of a student.

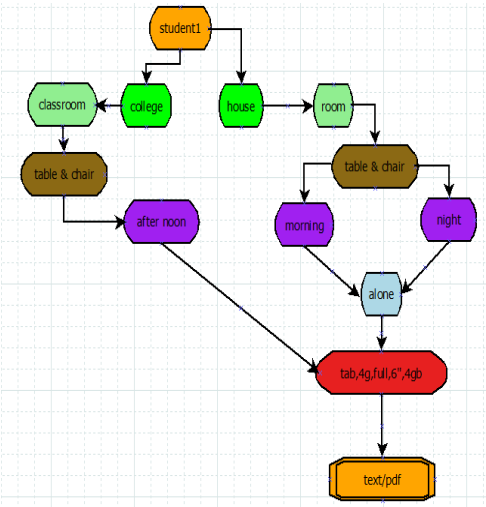

Fig. 1.Scenario of Student 1

Another similar scenario of student2 is represented in Fig. 2.

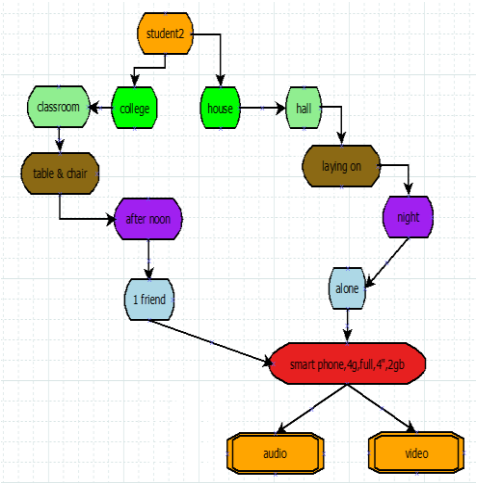

Fig. 2.Scenario of Student 2

The context of all the students and the content format they are interested have been collected. The students are interested in different formats of content relative to their day today contexts. Few sets of students are interested in fixed content formats and other set of students showed interest in mixed kind of content formats. The graph in Fig.3 depicts the formats of content accessed by different number of students. Content formats change with varying contexts of students in routine life.

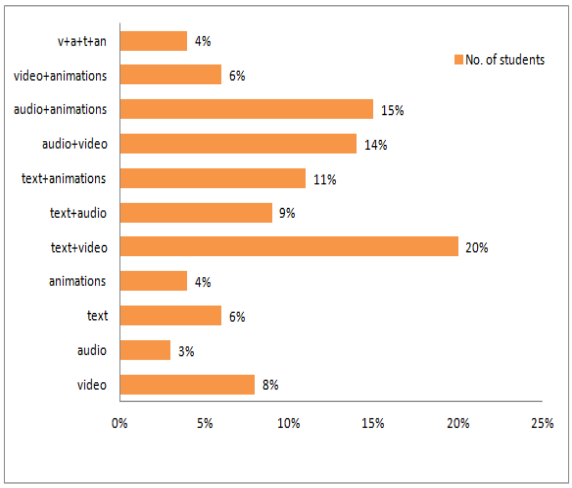

Fig.3. Content formats interested by number of students

III. THE CHI-SQUARE TEST

The Chi-Square Test of Independence decides if there is a relationship/association between categorical variables. This nonparametric test uses a contingency table to break down the data. A contingency table is a plan wherein data is grouped by two categorical variables. The classifications for one factor show up in the lines, and the classifications for the other variable show up in sections. Every factor must have at least two classifications. The Chi-Square Test of Independence can just analyze categorical variables. It can't make examinations between continuous variables or between categorical and continuous variables. . Furthermore, the Chi-Square Test of Independence just evaluates relationship between categorical variables, and can't give any deductions about causation.

The null hypothesis -H_0 and alternative hypothesis -H_1 of the Chi-Square Test of Independence can be put forth in two different but equivalent ways:

H_0: "[*Variable 1*] is independent of [*Variable 2*]"
H_1: "[*Variable 1*] is not independent of [*Variable 2*]"
OR
H_0: "[*Variable 1*] is not associated with [*Variable 2*]"
H_1: "[*Variable 1*] is associated with [*Variable 2*]"

The test statistic for the Chi-Square Test of Independence is denoted X^2, and is computed as in equation (i):

$$X^2 = \sum_{i=1}^{R}\sum_{j=1}^{C}\frac{(o_{ij}-e_{ij})^2}{e_{ij}} \quad \text{..... (i)}$$

where, o_{ij} is the observed cell count in the ith row and j^{th} column of the table and e_{ij} is the expected cell count in the ith row and j^{th} column of the table, computed as in equation (ii):

$$e_{ij} = \frac{row\ i\ total * col\ j\ total}{grand\ total} \quad \text{..... (ii)}$$

The quantity "(o_{ij} - e_{ij})" is referred to as the "residual of cell (i, j), denoted r_{ij}". The calculated X^2 value is then compared to the decisive value from the X^2 distribution table with degrees of freedom $df = (R - 1)(C - 1)$ and chosen confidence level. If the calculated X^2 value is greater than critical X^2 value, then decline the null hypothesis. The Chi-Square Test gives the "p" value ("p- is the probability the variables that are independent"). And if p is less than 0.05, it is the typical test for dependence. In case if p is greater than 0.05, then the variables are independent that is not associated together.

IV. Results and Discussions

The Chi-Square Test has been applied for the context variables to find the association and dependency with VARK variables. Two scenarios have been used for the test. One is the college scenario and second, the house scenario. Each scenario is analyzed in two parts.

The first part considers 3 important categorical variables "Gender", "Location" and "Timing" of all the students for the the Chi-Square test. The second part considers the sub categorical combined variables separately for the the Chi-Square test, for example, "only male students at library location" or "only female students at library at different timings".

A. Scenario I - College

Fig. 4(a) gives the male and female student ratio interested to study at college. Fig. 4(b) gives student ratios preferred to study at various locations of the college. Fig. 4(c) gives student ratios preferred to time at college.

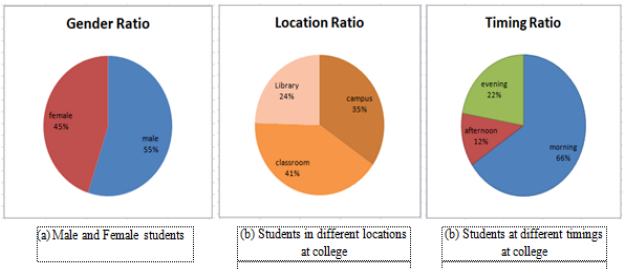

Fig.4. Student ratio – Gender, Location and Timing at college

From Table IV to VI give the hypothesis of individual variables, "Gender", "Location" and "Timing" against the "VARK" by finding the association and dependency through Chi Square Test.

Table IV: Hypothesis of Gender at College on VARK

	Male	female	Hypothesis
V	65	38	Since p>0.05 Gender and VARK are independent
A	50	49	
R	88	72	
K	77	75	
Chi square		4.634474	
Degree of freedom		3	
p =		0.200645	

Table V: Hypothesis of Location on VARK

	campus	classroom	library	Hypothesis
V	36	47	27	Since p<0.05 "Locations in college" and VARK are dependent and associated
A	38	58	14	
R	60	61	50	
K	44	44	35	
Chi square			14.5345	
Degree of freedom			6	
p =			0.0242032	

Table VI: Hypothesis of Timing on VARK

	morning	afternoon	evening	Hypothesis
V	74	12	24	Since p>0.05 timing and VARK are independent
A	77	13	20	
R	111	27	33	
K	75	11	37	
Chi square			8.71036	
Degree of freedom			6	
p =			0.190535	

Table VII and VIII give the hypothesis to find the inter dependency of "Gender" and "Location" variables combined together against "VARK" by finding the association and dependency through Chi Square test. Hypothesis of dependency of male students at various locations is calculated in Table VII. And hypothesis of dependency of female students at various locations is calculated in Table VIII.

Table VII: Hypothesis of Gender-Male at College Locations on VARK

	male_ classroom	male_ campus	male_ library	Hypothesis
V	31	25	16	Since p<0.05 "male-location" and VARK are dependent and associated
A	33	19	9	
R	30	34	24	
K	20	19	23	
Chi square			12.2198	
Degree of freedom			6	
p =			0.049	

Table VIII: Hypothesis of Gender-Female at College Locations on VARK

	female_ classroom	female_ campus	female_ library	Hypothesis
V	16	11	11	Since p>0.05 "female-location" and VARK are independent
A	25	19	5	
R	31	26	26	
K	24	25	12	
Chi square			9.76546	
Degree of freedom			6	
p =			0.134883	

The hypothesis to find the inter dependency of "Gender", "Location" and "Timing" variables combined together against "VARK" by finding the association and dependency through Chi Square Test is calculated . Hypothesis of dependency of male students at various locations at different timings is calculated from Table IX to Table XI.

Table IX: Hypothesis of Gender-Male at Library at different Timing on VARK

	male_ library_ morn	male_ library_ aft	male_ library_ even	Hypothesis
V	13	1	2	Since p<0.05 "male-library-timing" and VARK are dependent and associated
A	6	0	3	
R	9	8	7	
K	9	4	10	
Chi square			13.7287	
Degree of freedom			6	
p =			0.0328177	

Table X: Hypothesis of Gender-Male at Campus at different Timing on VARK

	male_ campus_ morn	male_ campus_ aft	male_ campus_ even	**Hypothesis**
V	14	5	6	Since p>0.05 "male-campus-timing" and VARK are independent
A	11	2	6	
R	14	3	6	
K	10	1	8	
Chi square			3.41526	
Degree of freedom			6	
p =			0.755208	

Table XI: Hypothesis of Gender-Male at Classroom at different Timing on VARK

	male_ classroom_ morn	male_ classroom _aft	male_ classroo m_ even	**Hypothesis**
V	20	5	6	Since p>0.05 "male-classroom-timing" and VARK are independent
A	25	3	5	
R	24	2	4	
K	18	0	2	
Chi square			5.719	
Degree of freedom			6	
p =			0.455393	

Hypothesis of dependency of female students at various at different timings is calculated from Table XII to Table XIV.

Table XII: Hypothesis of Gender-Female at Library at different Timing on VARK

	female_ library_ morn	female_ library_ aft	female_ library_ even	**Hypothesis**
V	8	0	3	Since p>0.05 "female-library-timing" and VARK are independent
A	2	2	1	
R	21	2	3	
K	8	1	3	
Chi square			8.65241	
Degree of freedom			6	
p =			0.190535	

Table XIII: Hypothesis of Gender-Female at Classroom at different Timing on VARK

	female_classroom_morn	female_classroom_aft	female_classroom_even	**Hypothesis**
V	13	5	3	Since p<0.05 "female-classroom-timing" and VARK are dependent and associated
A	23	0	1	
R	27	0	4	
K	19	1	3	
Chi square			22.0614	
Degree of freedom			6	
p =			0.00118022	

Table XIV: Hypothesis of Gender-Female at Campus at different Timing on VARK

	female_ campus _morn	female_campus_aft	female_ campus _even	**Hypothesis**
V	6	1	4	Since p<0.05 "female-campus-timing" and VARK are dependent and associated
A	10	5	4	
R	5	12	9	
K	11	3	11	
Chi square			13.1263	
Degree of freedom			6	
p =			0.0410732	

B. Scenario II - House:

Fig. 5(c) gives the male and female student ratio interested to study at house. Fig.5(b) gives student ratios preferred to study at various locations of the house. Fig. 5(a) gives student ratios preferred to time at house.

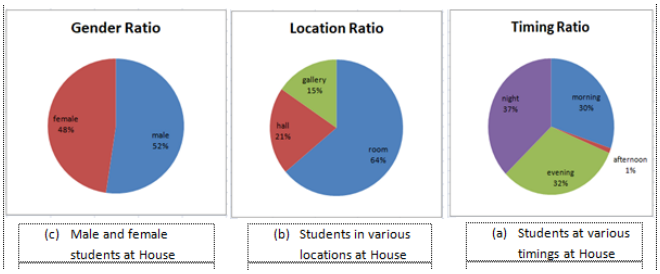

Fig.5. Student ratio – Gender, Location and Timing at House

From Table XV to Table XVII give the hypothesis of individual variables, "Gender", "Location" and "Timing" at house against the "VARK" by finding the association and dependency through Chi Square Test.

Table XV: Hypothesis of Gender at House on VARK

	male	female	Hypothesis
V	82	57	Since p<0.05 Gender and VARK are dependent and associated
A	38	16	
R	75	85	
K	74	87	
Chi square		14.0441	
Degree of freedom		3	
p =		0.0028458	

Table XVI: Hypothesis of Location at House on VARK

	gallery	hall	room	Hypothesis
V	22	28	89	Since p<0.05 "location" and VARK are dependent and associated
A	6	15	33	
R	17	30	113	
K	34	35	92	
Chi square			18.5986	
Degree of freedom			6	
p =			0.00489799	

Table XVII: Hypothesis of Timing at House on VARK

	morning	afternoon	evening	night	Hypothesis
V	50	6	40	44	Since p<0.05 timing and VARK are dependent
A	15	8	11	21	
R	32	6	59	60	
K	43	8	45	66	
Chi square			23.004		
Degree of freedom			9		
p =			0.00618743		

From Table XVIII to Table XX, give the hypothesis to find the inter dependency of "Gender-Male", at various locations of house at different timings are combined together against "VARK" by finding the association and dependency through Chi Square Test.

Table XVIII: Hypothesis of Gender-Male at Room at different Timing on VARK

	male_ room_mor n	male_ room_a ft	male_ room_ evn	male _ room _ nit	Hypothesis
V	15	6	11	17	Since p>0.05 "male-room-timing" and VARK are independent
A	10	7	7	14	
R	7	6	15	25	
K	14	8	10	20	
Chi square			7.19909		
Degree of freedom			9		
p =			0.6164		

Table XIX: Hypothesis of Gender-Male at Hall at different Timing on VARK

	male_ hall_ morn	male_hall _aft	male_ha ll_evn	male_hall _nit	Hypothesis
V	9	0	6	2	Since p cannot be calculated ; "male-hall-timing" and VARK are independent
A	3	0	1	4	
R	4	0	5	5	
K	1	0	0	8	
Chi square			NAN		
Degree of freedom			9		
p =			NAN		

Table XX: Hypothesis of Gender-Male at Gallery at different Timing on VARK

	male_galler y_morn	male_ galler y_aft	male_gall ery_eve	male_gall ery_nit	Hypothesis
V	1	0	7	2	Since p cannot be calculated ; "male-gallery-timing" and VARK are independent
A	3	1	0	3	
R	0	0	0	0	
K	6	0	0	4	
Chi square			NAN		
Degree of freedom			9		
p =			NAN		

And hypothesis of dependency of "Gender-Female" students at various locations at different timings at house is calculated from Table XXI to Table XXIII.

Table XXI: Hypothesis of Gender-Female at Room at different Timing on VARK

	female_ room_m orn	female_ room_a ft	female_ro om_evn	femal e_roo m_nit	Hypothesis
V	16	0	5	13	Since p cannot be calculated ; "female-room-timing" and VARK are independent
A	3	0	1	0	
R	21	0	23	16	
K	6	0	17	15	
Chi square			NAN		
Degree of freedom			9		
p =			NAN		

Table XXII: Hypothesis of Gender-Female at Hall at different Timing on VARK

	female_hal l_morn	female_h all_aft	female_ha ll_evn	femal e_hal l_nit	Hypothesis
V	12	0	7	15	Since p cannot be calculated ; "female-hall-timing" and VARK are independent
A	3	0	1	0	
R	20	0	24	16	
K	8	0	15	15	
Chi square			NAN		
Degree of freedom			9		
p =			NAN		

Table XXIII: Hypothesis of Gender-Female at Gallery at different Timing on VARK

	femal e_gal lery_ morn	female _galler y_aft	female _galler y_eve	female_ gallery_ nit	Hypothesis
V	10	0	8	16	Since p cannot be calculated ; "female-gallery-timing"
A	3	0	1	0	
R	20	0	20	20	

K	8	0	15	15	and VARK are independent
Chi square			NAN		
Degree of freedom			9		
p =			NAN		

The overall impression of dependency and association between VARK and independent variables with respect to the hypothesis, computed above, is summarized in Table XXIV. It can be found that for college scenario only "Location" variable affects the VARK styles and for the house scenario all the three variables "Gender", "Location" and "Timing" affect the "VARK" styles of students.

Table XXIV : Hypothesis of independent variables at College and House

College		House	
Independent Variables	***VARK***	***Independent Variables***	***VARK***
Gender		Gender	D&A
Location	D&A	Location	D&A
Timing		Timing	D&A

- **D&A stands for "Dependent and Associated"**

Table XXV summarizes the hypothesis of combined variables for the college and house scenarios. The variable "Gender combined with Location" i.e. "Male students at preferred various Locations at college", affects the choice of VARK styles. The variable "Gender combined with particular Location and different Timing" has been analyzed and found that "Male students at Library at different Timing" affect the VARK styles. And also the variables "Female students at Classroom at different Timing" and "Female students at Campus at different Timing" make impact on the VARK choices at college. But none of the variables at house impact on the VARK choices at house scenario.

Table XXV: Hypothesis of inter dependent or combined variables at College and House

College		House	
Combined Variables	***VARK***	***Combined Variables***	***VARK***
male-location	D&A	male-room-timing	
female-location		male-hall-timing	
male-library-timing	D&A	male-gallery-timing	
male-campus-timing		female-room-timing	
male-classroom-timing		female-hall-timing	
female-library-timing		female-gallery-timing	
female-classroom-timing	D&A		
female-campus-timing	D&A		

- **D&A stands for "Dependent and Associated"**

V. CONCLUSION

In this article, effect of context of learners on the VARK learning styles has been conducted by Chi Square Test for M-Learning environment. The college and house contexts with various categorical variables have been collected by the engineering students for "C programming subject" assuming for M-Learning system. Students have given their context preferences and preferred VARK learning styles. The Chi Square test has been conducted to find the association and dependencies between these categorical context variables and VARK styles. For the college context the variables, "Location", "Male students in Library" and "Female students in Classroom and Campus" make impact on choosing the VARK style. And for the house context the individual variables "Gender", "Location" and "Timing" separately make impact on choosing the VARK styles.

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