ETW3510_Applied Econometrics Methods

Assessment_01:Logit/Probit Model

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Introduction:

Is Malaysia actually achieving fair education provision regardless of vulnerability? From the research paper 'Use of ICT in Primary School' published in May 2012 by Dipak Kawade at Sangola College, important benefits of ICT usage has been suggested not only in aspect of teachers and official procedure of school but also study engagement of students with higher education quality (Dipak, 2012).

While the paper focuses on the case of primary school in Indian agricultural region, it makes clear point about importance of ICT usage in primary education for vulnerable community student in Malaysia especially Indian Malaysian students. In fact, approximately 6.6 per cents of population in Malaysia are Indian groups (Ministry of Economy Department of Statistics Malaysia Portal, 2022). Referring to report published by UNICEF, Malaysian Education goal aligns with 4th goals of Sustainable Development Goals which is 'Quality Education' (Unicef, n.d). If those 6.6 per cents of population does not get appropriate education due to short access to ICT, this 4th SDG would not be accomplished.

Therefore, the current research will provide insights about ICT education opportunity provision for primary students in Malaysia and the result will be used as a fundamental to successfully accomplish the 'Quality Education' goal in Malaysia.

Exploratory Data Analysis:

#	Use	Age	PerfExp	EffExp	SI.Family	SI.Teachers	SI.Peers	FC.Ext	FC.Int
	0	11.0	2.84	2.90	2.98	3.00	2.99	3.00	3.02
	1	11.0	3.17	3.10	3.02	2.97	3.07	2.90	2.78

Referring to the average value charts of none-discrete values, mean value of each variables does not show significant differences depending on 'Use' of ICT technologies. In the chart, 0 means ‘Not_Frequent’ usage of ICT and 1 means ‘Frequent’ usage of ICT technologies. Therefore, it is concluded that the data is not binary depending on the dependent variable ‘Use’.

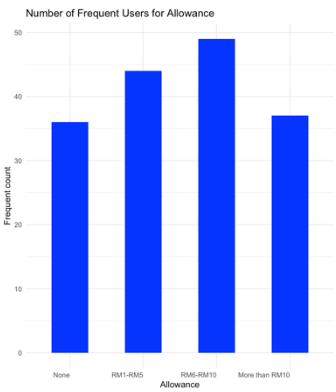
Characteristic		N = 3801	
Age		**Allowance**	
10	117 (31%)	More than RM10	77 (20%)
11	148 (39%)	None	79 (21%)
12	115 (30%)	RM1-RM5	112 (29%)
Gender		RM6-RM10	112 (29%)
Female	190 (50%)	**Location**	
Male	190 (50%)	Rural	193 (51%)
		Urban	187 (49%)

The frequency table of discrete table reveals about count number and percentage which values of each variables are taking from the variable set. In the table, ‘Age’ is included despite it is continuous variable since there were only three ages. Therefore, 11 years old students were observed the most with 39 percent of entire student. There are equal amount of ‘Male’ and ‘Female’ students, and most of students are getting ‘RM1-RM5’ or ‘RM6-RM10’ ‘Allowance’ with 29 percents for each. Lastly, there are 6 more students from ‘Rural’ area than ‘Urban’ area which is 2 percents higher. Thus, this observation is not expected to impact binarity of the data since it is small difference.

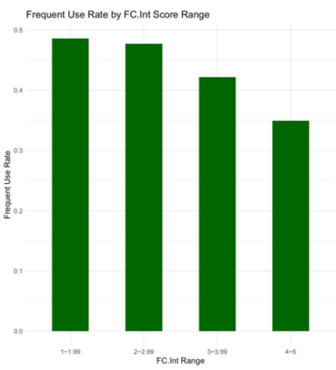
‘Use’ table

	Frequent	Not_frequent
Count	164	216
Prob	0.4315789	0.5684211

Lastly, there are 164 ‘Frequent’ use of ICT observations which takes 43.16 percents of population and 216 ‘Not_frequent’ use of ICT observations which takes 56.84 percents of population.

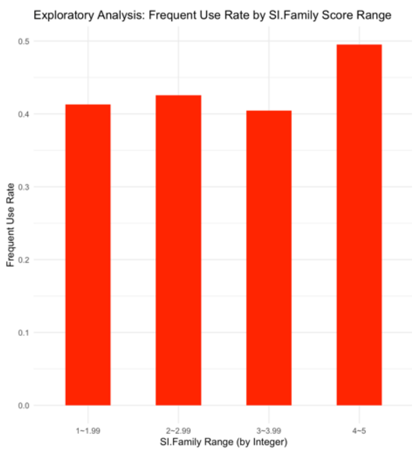


Visualisation of ‘Allowance’ and ‘Frequent’ use count relationship reveals positive proportion between them. As students are using ICT more in education seem they are getting more allowance. However, when they start getting allowance of more than RM10, ICT usage tends to decrease ironically.



Visualization of ‘FC.Int’ between “Frequent’ use frequency rate is showing inverse proportion. ‘FC.Int’ variable reveals how students are perceiving about their ICT supporting for education. Meaning that, higher ‘FC.Int’ means students are feeling that they are getting enough supporting for ICT usage and vise versa. However, the graph shows that, students are using ICT more as they are feeling they are not getting enough equipment. Conducting analysis of the data, as students use computer more, they would know further functions of computers and naturally wants better equipment for higher performance. Therefore, more they use, more they know, more they want, and they are feeling the equipment is not enough for them.

(when there is more number of usage of ICT, demand of ICT also increases and their satisfaction level relatively decrease.)



'SI.Family' variable is about whether students perceive they are getting enough encouragement of using computer from their family. Since family give large effect to student when they are growing, effect of family is not neglectable. From the visualization the variable family encouragement does not show impressive effect to their computer usage however, when it goes over 4, it increases computer usage nearly 50 percents.

Empirical Analysis:

- **Logistic model selection**

Logistic model has been made with every collaboration of independent variable choice. Each logistic model has different combination of independent variables

Logit model Comparison

	logit_model_01	logit_model_02	logit_model_03	logit_model_04	logit_model_05	logit_model_06
AIC	526.7262	521.6481	527.5625	522.9928	527.5626	522.9927
BIC	570.0681	564.99	570.9044	566.3346	570.9045	566.3345
log-lik	-252.3631	-249.8241	-252.7812	-250.4964	-252.7813	-250.4963
McFadden's R^2	0.03070074	0.04045296	0.02909473	0.03787064	0.02909452	0.03787082
Accuracy	59.21	63.68	60	63.68	60	63.95

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Coefficients:
                    Estimate   Std.Error  z value    Pr(>|z|)
(Intercept)        -1.446234   1.682482   -0.860    0.39002
Age                 0.008396   0.139268    0.060    0.95192
GenderMale          0.055091   0.214564    0.257    0.79737
AllowanceNone      -0.110416   0.330020   -0.335    0.73795
AllowanceRM1-RM5   -0.304660   0.310061   -0.983    0.32581
AllowanceRM6-RM10  -0.175326   0.305793   -0.573    0.56641
LocationUrban       0.290442   0.215000    1.351    0.17673
PerfExp             0.291826   0.094223    3.097    0.00195 **
EffExp              0.166484   0.095081    1.751    0.07995 .
SI.Family           0.107520   0.092896    1.157    0.24710
FC.Int             -0.214803   0.095864   -2.241    0.02505 *
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Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 520.71  on 379  degrees of freedom
Residual deviance: 499.65  on 369  degrees of freedom
AIC: 521.65

Number of Fisher Scoring iterations: 4
```

Comparing each logistic models, 'logit_model_02' has the lowest AIC, BIC and the highest log-likelihood, McFadden's R^2, and Accuracy rate. Therefore, 'logit_model_02' has been selected among logistic models.

$$logit(\Pr(\text{Use} = 1)) =$$

$$\beta0(-0.33257) + \beta1(-0.06717) \cdot \text{Age} + \beta2(0.03798) \cdot \text{GenderMale} + \beta3(-0.22448) \cdot \text{AllowanceNone} + \beta4(-0.31479) \cdot \text{AllowanceRM1} - \text{RM5} + \beta5(-0.25380) \cdot \text{AllowanceRM6} - \text{RM10} + \beta6(0.21375) \cdot \text{LocationUrban} + \beta7(0.27671) \cdot \text{PerfExp} + \beta8(0.16383) \cdot \text{EffExp} + \beta9(0.06912) \cdot SI.Family + \beta10(-0.21157) \cdot FC.Int$$

- **Probit Model Selection**

Probit model has been created with every possible combinations of independent variables. The chart below compares the statistical values of each probit models.

Probit Model comparison

	probit_model_01	probit_model_02	probit_model_03	probit_model_04	probit_model_05	probit_model_06
AIC	526.8004	521.8811	527.6172	523.2276	527.6173	523.2276
BIC	570.1423	565.223	570.959	566.5695	570.9592	566.5694
log-lik	-252.4002	-249.9405	-252.8086	-250.6138	-252.8087	-250.6138
McFadden's R^2	0.03055833	0.04000558	0.02898972	0.03741969	0.02898942	0.03741971
Accuracy	59.21	63.42	59.74	63.95	60	63.95

Considering the lowest AIC, BIC and the highest log-likelihood, McFadden's R^2, and Accuracy rate, 'probit_model_2' has been selected as the best probit model.

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Coefficients:
                  Estimate  Std. Error  z value  Pr(>|z|)
(Intercept)      -0.915358   1.039543   -0.881   0.37857
Age               0.007714   0.086037    0.090   0.92856
GenderMale        0.035861   0.132430    0.271   0.78655
AllowanceNone    -0.060834   0.203889   -0.298   0.76542
AllowanceRM1-RM5 -0.191073   0.191308   -0.999   0.31791
AllowanceRM6-RM10 -0.106369  0.188836   -0.563   0.57324
LocationUrban     0.174902   0.132845    1.317   0.18798
PerfExp           0.178531   0.057818    3.088   0.00202 **
EffExp            0.100825   0.058602    1.721   0.08534 .
SI.Family         0.066339   0.057306    1.158   0.24701
FC.Int           -0.130232   0.058956   -2.209   0.02718 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 520.71  on 379  degrees of freedom
Residual deviance: 499.88  on 369  degrees of freedom
AIC: 521.88

Number of Fisher Scoring iterations: 4
```

$$\Pr(\text{Use} = 1) =$$

$$\Phi(\beta0(-0.21279) + \beta1(-0.04051) \cdot \text{Age} + \beta2(0.02253) \cdot \text{GenderMale} + \beta3(-0.13477) \cdot \text{AllowanceNone} + \beta4(-0.19769) \cdot \text{AllowanceRM1} - \text{RM5} + \beta5(-0.15522) \cdot \text{AllowanceRM6} - \text{RM10} + \beta6(0.13063) \cdot \text{LocationUrban} + \beta7(0.17018) \cdot \text{PerfExp} + \beta8(0.09957) \cdot \text{EffExp} + \beta9(0.04330) \cdot SI.Family + \beta10(-0.12957) \cdot FC.Int)$$

- **Choice of variables**

Among other variables, the chosen variables are ‘SI.Family’ and ‘FC.Int’ variable.

Since students are underage grade 5~6 which their identity is not completely formed yet, effect of family crucial. Considering these circumstances, the variable stands for family effect has been selected.

Selection of ‘FC.Int’ gives higher importance of interior perception of supporting which students get. Internal supporting is visible effect which students can feel and see physically. Therefore, ‘FC.Int’ is taken as regressor while effect of internal supporting might be more crucial than external supporting which students may not actively realize..

- **Ultimate model selection**

	logit_model	Probit model
AIC	521.6481	521.8811
BIC	564.99	565.223
log-lik	-249.8241	-249.9405
McFadden's R²	0.04045296	0.04000558
Accuracy	63.68	63.42

Reviewing the AIC, BIC, Log-likelihood, McFadden’s R^2, and Accuracy rate, logit model is considered as the ultimate model. However, not considering the statistical value only but also feature of each models, logistic model follows odds ratio so that the interpretation could be clear for conclusion.

$$logit(\text{Pr}(\text{Use} = 1)) =$$

$$\beta0 + \beta1 \cdot \text{Age} + \beta2 \cdot \text{GenderMale} + \beta3 \cdot \text{AllowanceNone} + \beta4 \cdot \text{AllowanceRM1} - \text{RM5} +$$

$$\beta5 \cdot \text{AllowanceRM6} - \text{RM10} + \beta6 \cdot \text{LocationUrban} + \beta7 \cdot \text{PerfExp} + \beta8 \cdot \text{EffExp} +$$

$$\beta9 \cdot SI.Family + \ \beta10 \cdot FC.Int$$

- **Hypothesis Test of Joint Significance**

$$H_0: \beta_1 = \beta_2 = \beta_3 = \cdots = \beta_{10} = 0$$
$$H_1: at\ least\ one\ of\ \beta_i \neq 0\ for\ i = 1,2,3, \ldots, 10$$

	LU	LR
value	-251.2115	-260.6049
calc		18.7867
crit		18.30704

since, ‘LR_calc’ is larger than ‘LR_crit’ value, the null hypothesis is rejected and concluded that the model is statistically valid.

- **The most significant Variable**

	Dependent variable: Use
Age	0.008 (0.139)
GenderMale	0.055 (0.215)
AllowanceNone	-0.110 (0.330)
AllowanceRM1-RM5	-0.305 (0.310)
AllowanceRM6-RM10	-0.175 (0.306)
LocationUrban	0.290 (0.215)
PerfExp	0.292*** (0.094)
EffExp	0.166* (0.095)
SI.Family	0.108 (0.093)
FC.Int	-0.215** (0.096)
Constant	-1.446 (1.682)
Observations	380
Log Likelihood	-249.824
Akaike Inf. Crit.	521.648
Note:	*p<0.1; **p<0.05; ***p<0.01

Estimator

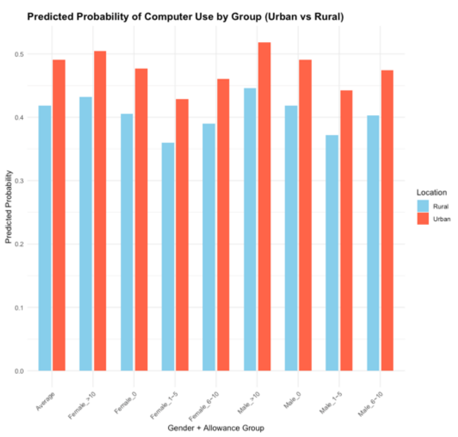
factor	AME	SE	z	p	lower	upper
Age	0.0020	0.0324	0.0603	0.9519	-0.0616	0.0655
AllowanceNone	-0.0260	0.0776	-0.3347	0.7378	-0.1781	0.1262
AllowanceRM1-RM5	-0.0710	0.0721	-0.9841	0.3251	-0.2123	0.0704
AllowanceRM6-RM10	-0.0411	0.0717	-0.5735	0.5663	-0.1818	0.0995
EffExp	0.0387	0.0218	1.7783	0.0753	-0.0040	0.0814
FC.Int	-0.0500	0.0217	-2.2988	0.0215	-0.0926	-0.0074
GenderMale	0.0128	0.0499	0.2568	0.7973	-0.0850	0.1106
LocationUrban	0.0680	0.0503	1.3518	0.1764	-0.0306	0.1665
PerfExp	0.0679	0.0208	3.2570	0.0011	0.0270	0.1088
SI.Family	0.0250	0.0215	1.1653	0.2439	-0.0171	0.0671

Reviewing the statistical table of ultimate chosen estimator, ‘AllowanceRM1-RM5’ has the largest absolute value of coefficient and Average Marginal Effect. However, considering its p-value greater than 0.05, its might be happened by a random chance. Therefore, taking p-values into account, ‘PerfExp’ variable is considered as the most effective variable in the model since it has the largest coefficient and Average Marginal Effect value among p-values smaller than 0.05 to prove its reasonability.

Therefore, ‘PerfExp’ stands for student’s opinion whether learning computer enhanced their education, it has been concluded that student’s own motivation about the education is the most important factor among other conditions. When students find value of education, its effect will be enlarged enormously.

- **Visualization of computer usage by Location:**

	Urban	Rural
Male_Allowance 0	0.490614	0.4187298
Male_Allowance 1~5	0.4423099	0.37233
Male_Allowance 6~10	0.4744079	0.4030195
Male_Allowance >10	0.5182089	0.4030195
Female_Allowance 0	0.4768567	0.405384
Female_Allowance 1~5	0.428767	0.3595483
Femael_Allowance 6~10	0.4606941	0.3898387
Female_Allowance >10	0.5044441	0.432253
Average	0.490614	0.4187298

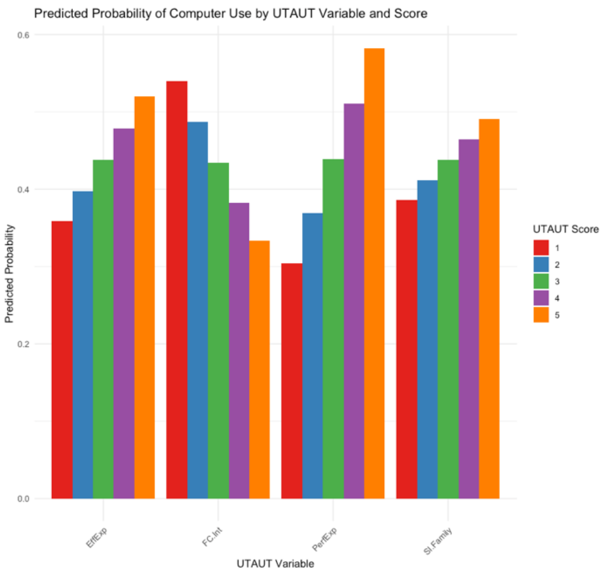


Based on the ultimate estimator model chosen, probability of frequently using computer has been predicted by location for every possible combination of discrete variables which other continuous variables are converted into mean value.

Based on the 'Average' column of the visualization, Location gives effect to computer usage. Besides, male student who gets allowance more than RM10 and living in urban area uses computer the most frequently and female students who gets allowance RM1~RM5 and living in the rural area uses computer the least frequently.

Overall, urban collum is higher than rural column in every sort of students. Therefore, regardless of allowance or gender, urban location gives a great benefit in using computers.

- **Visualization of probability of computer use across the range of UTAUR variable values.**



This visualization is about probability of computer use across the range of UTAUR variables. Each column represents the average predicted probability calculated across all possible combinations of demographic variables for the corresponding UTAUT score.

For 'EffExp' which stands for perception of student about degree of ease and effort they must put in to use ICT for education, the probability increases as the score increases too. Meaning that, more they feel about effort to use computers, they use computers more for learning.

For 'FC.Int' variables which stands for student's perception about their internal supporting of ICT usage, its score and computer use shows negative relationship. As it has been explained, it is analyzed as, when students use computer more, they may know there are higher functions of computer and their desire of better equipment and supporting may be revealed in the negative relationship of 'FC.Int' and 'Use' variable.

For 'PerfExp' which stands for student's belief about value of computer use for their learning, it shows a strong positive relation between probability of computer use. More they feel useful about computer use for their learning, they use computers more. As long as this is the strongest positive relationship, student's own motivation seems the most important among all the other factors.

For 'SI.Family' variable which stands for student's perception about family engagement about computer use for their learning, it shows positive proportional relationship with probability of computer use. If student's age is the age which they get the strongest effect from family, behavior of family about computer use may act crucially. With strong family support, students are expected to use computer more for their learning.

- **Average Partial Effect of two significant non-discrete variables:**

	Dependent variable: Use
Age	0.008 (0.139)
GenderMale	0.055 (0.215)
AllowanceNone	-0.110 (0.330)
AllowanceRM1-RM5	-0.305 (0.310)
AllowanceRM6-RM10	-0.175 (0.306)
LocationUrban	0.290 (0.215)
PerfExp	0.292*** (0.094)
EffExp	0.166* (0.095)
SI.Family	0.108 (0.093)
FC.Int	-0.215** (0.096)
Constant	-1.446 (1.682)
Observations	380
Log Likelihood	-249.824
Akaike Inf. Crit.	521.648
Note:	*p<0.1; **p<0.05; ***p<0.01

Estimator

factor	AME	SE	z	p	lower	upper
Age	0.0020	0.0324	0.0603	0.9519	-0.0616	0.0655
AllowanceNone	-0.0260	0.0776	-0.3347	0.7378	-0.1781	0.1262
AllowanceRM1-RM5	-0.0710	0.0721	-0.9841	0.3251	-0.2123	0.0704
AllowanceRM6-RM10	-0.0411	0.0717	-0.5735	0.5663	-0.1818	0.0995
EffExp	0.0387	0.0218	1.7783	0.0753	-0.0040	0.0814
FC.Int	-0.0500	0.0217	-2.2988	0.0215	-0.0926	-0.0074
GenderMale	0.0128	0.0499	0.2568	0.7973	-0.0850	0.1106
LocationUrban	0.0680	0.0503	1.3518	0.1764	-0.0306	0.1665
PerfExp	0.0679	0.0208	3.2570	0.0011	0.0270	0.1088
SI.Family	0.0250	0.0215	1.1653	0.2439	-0.0171	0.0671

Based on the statistical table, coefficient, Average Marginal Effect, and p-value has been considered to choose two significant variable.

Among the variables with p-value lower than 0.05, 'PerfExp' and 'FC.Int' has been selected as the most significant variables with the largest absolute value of coefficient and Average Marginal Effect.

- **Calculation of Average Partial Effect of 'PerfExp'.**

$$APE_{\text{PerfExp}} = \left(\frac{1}{n}\sum_{i=1}^{n} g\left(\widehat{\beta_0} + x_i'\hat{\beta}\right)\right) * \widehat{\hat{\beta}_{\text{PerfExp}}}$$

$$APE_{\text{PerfExp}} = \left(\frac{1}{n}\sum_{i=1}^{n} \theta\left(\widehat{\beta_0} + x_i'\hat{\beta}\right)\right) * \widehat{\hat{\beta}_{\text{PerfExp}}}$$

$$APE_{\text{PerfExp}} = \left(\frac{1}{n}\sum_{i=1}^{n} \frac{exp\left(\widehat{\beta_0} + x_i'\hat{\beta}\right)}{\left[1 + \left(\widehat{\beta_0} + x_i'\hat{\beta}\right)\right]^2}\right) * \widehat{\hat{\beta}_{\text{PerfExp}}}$$

$$APE_{\text{PerfExp}} = (0.2326525) * \ 0.291826$$

$$APE_{\text{PerfExp}} = 0.06789413$$

$$APE_{\text{PerfExp}} = 0.0679$$

- **Calculation of Average Partial Effect of 'FC.Int'.**

$$APE_{\text{FC.Int'}} = \left(\frac{1}{n}\sum_{i=1}^{n} g\left(\widehat{\beta_0} + x_i'\hat{\beta}\right)\right) * \ \widehat{\hat{\beta}_{\text{FC.Int'}}}$$

$$APE_{\text{FC.Int'}} = \left(\frac{1}{n}\sum_{i=1}^{n} \theta\left(\widehat{\beta_0} + x_i'\hat{\beta}\right)\right) * \ \widehat{\hat{\beta}_{\text{FC.Int'}}}$$

$$APE_{\text{FC.Int'}} = \left(\frac{1}{n}\sum_{i=1}^{n} \frac{exp\left(\widehat{\beta_0} + x_i'\hat{\beta}\right)}{\left[1 + \left(\widehat{\beta_0} + x_i'\hat{\beta}\right)\right]^2}\right) * \ \widehat{\hat{\beta}_{\text{FC.Int'}}}$$

$$APE_{\text{FC.Int'}} = (0.2326525) * (-0.2148027\ )$$

$$APE_{\text{FC.Int'}} = -0.0499744$$

$$APE_{\text{FC.Int'}} = -0.05$$

- **Case application of the logistic estimator model.**

$$l\text{ogit}(\Pr(\text{Use} = 1)) =$$

$$\beta0 + \beta1 \cdot \text{Age} + \beta2 \cdot \text{GenderMale} + \beta3 \cdot \text{AllowanceNone} +$$

$$\beta4 \cdot \text{AllowanceRM1} - \text{RM5} + \beta5 \cdot \text{AllowanceRM6} - \text{RM10} +$$

$$\beta6 \cdot \text{LocationUrban} + \beta7 \cdot \text{PerfExp} + \beta8 \cdot \text{EffExp} +$$

$$\beta9 \cdot SI.Family + \ \beta10 \cdot FC.Int$$

The situation is for a 12 years old female student from a rural school who gets weekly allowance of RM1~RM5 with average values for UTAUT variables.

The estimator would be:

$$logit(\Pr(\text{Use} = 1)) =$$

$$(-1.446234) + \beta1(0.008396) \cdot \text{Age}(12) + \beta2(0.055091) \cdot \text{GenderMale}(1) + \beta3(-0.110416) \cdot \text{AllowanceNone}(0) +$$

$$\beta4(-0.304660) \cdot \text{AllowanceRM1} - \text{RM5}(1) + \beta5(-0.175326) \cdot \text{AllowanceRM6} - \text{RM10}(0) +$$

$$\beta6(0.290442) \cdot \text{LocationUrban}(0) + \beta7(0.291826) \cdot \text{PerfExp}(3.002553) + \beta8(0.166484) \cdot \text{EffExp}(3.025342) +$$

$$\beta9(0.107520) \cdot SI.Family(3.032026) + \beta10(-0.214803) \cdot FC.Int(2.908211)$$

$$= 0.3665382$$

$$= 36.6538\%$$

Therefore, the probability of a female student from rural area school who gets RM1~RM5 weekly allowance with average values for UTAUT scores uses computer for her learning is approximately 36.6538 per cents.

CONCLUSION:

From the research, UTAUT scores gives definite effect to computer use to students for their learning. Beside of demographic information, UTAUT score provided insights to suggest practical policies.

Reviewing 'EffExp' score, government may lead computer education to approach to students in easy manner to obtain their sustainable interest. As 'PerfExp' and 'SI.Family' score showed strong positive relationship with computer use, it is crucial to educate students about utility and possibilities for their successful life from learning computer technologies. However, considering 'SI.family' score, students are not only object of education but also parents. Schools may send letter about importance of learning computers in the modern days so that students get enough supporting from their family.

When students find worth of learning computer with enough family support, they will be able to use computer in wider spectrums for their learnings and life. Ultimately it will help vulnerable community students to stay active in the modern technological society.

Lastly, 'FC.Int' gives insight which students who feel lack of supporting are actually using computer more. On the inverse perspective, student without much knowledge about the computer may not know possibilities of computer learning beyond their reality and satisfy about their situation since they do not see what is beyond of it. Therefore, education ministry may allocate budgets to high ‘FC.Int’ score school to provide equipment for computer learning to show more possible performances beyond their situation. They will find what they can do with new equipment and finally demand better supporting while students are willing to perform higher.

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