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Factors influencing design thinking ability in modelling climate smart agricultural practices by under-graduate agriculture students of central agricultural university Imphal: a binary logistic regression modeling

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Abstract
Design thinking a modern human centered problem-solving concept that can be used in the face of complex problems is expected to create meaningful innovations after internalizing the problems of farmers and associating them with Climate Smart Agricultural Practices which is offering array of solutions to enable farmers mitigate the problems of Climate Change. The study aims to identify factors influencing Design Thinking ability among undergraduate students of agriculture in modelling Climate Smart Agricultural Practices. This inquiry was conducted at three Colleges of Agriculture under Central Agricultural University, Imphal, in which B.Sc. (Agriculture) degree is provided. Total of 28 final year students have been randomly selected as respondents for the study. Nine independent variable *viz.*, Age, Gender; OGPA; Competency on ICT; Creative Problem Solving; Ability to Visualize Abstract Ideas; Memory Retention, Aptitude & Reading Behavior; and one dependent variable *viz.* Operationalization of Design Thinking were considered in the scientific inquiry. The binary logistic regression model was significant at p = 0.037 with AIC & BIC values of 40.86 & 54.18, respectively indicating moderate acceptable explanations of independent variables on outcome of dependent variable. With the subsequent Cox & Snell R^2 and Nagelkerke R^2 values of 0.471 and 0.629, revealed that the independent variables interacted and explained the significant outcome of the dependent variable in the range of 47.10 to 62.90%. The model identified; Age; Gender; OGPA and Creative Problem Solving had significant effect on Design Thinking. The study suggested that strategies need to be focused on development of students' Aptitude; Competency on ICT, Memory Retention; Ability to Visualize Abstract Ideas and Reading Behavior.

Keywords: Binary logistic regression, climate change, college of agriculture, climate smart Agricultural practices, design thinking, cox & Snell R^2 and Nagelkerke R^2

1. Introduction
In the endeavor of agricultural universities to develop highly competent agricultural graduates who can address the challenges of 21st century, especially those posed by Climate change (CC) which is adversely affecting the society in terms of food security, Climate Smart Agricultural Practices (CSAPs) although providing an opportunity for a triple win apropos of Productivity, Adaptation and Mitigation, there remains inadequacy in achieving the goal due to improper modelling of CSAPs technologies. The Design Thinking (DT) which is a method for developing an innovative solution for complex problems by deliberately incorporating concerns on interest and values of human into the design process [1, 2] by developing and testing multiple possible solutions [3], has been underscored into consideration in the scientific study to understand the dynamics of DT by undergraduate agriculture students to model CSAPs that best suits them in becoming a Climate Smart Design Thinker in mitigation & adapting CC in agriculture. The objective of the research was to identify factors influencing DT ability in modelling CSAPs by Under-Graduate agriculture students of Central Agricultural University, Imphal (CAU, I).

2. Materials and Methods
The study was conducted at three Colleges of Agriculture (CoA) under CAU, I *viz.*, College of Agriculture, Imphal (CoA, I), College of Agriculture, Pasighat (CoA, P) and College of Agriculture, Kyrdemkulai (CoA, K) as these three institutes offer B.Sc. (Agriculture) degree.

The respondents of the study were B.Sc. final year students. The 50% of the total class strength in each college were selected by following simple random sampling without replacement, resulting a distribution of 13, 8, and 7 respondents from CoA, I; CoA, P; and CoA, K, respectively. Thereby constituting a total of 28 students as sample size of the study. Nine independent variable *viz.*, Age, Gender; OGPA; Competency on ICT; Creative Problem Solving; Ability to Visualize Abstract Ideas; Memory Retention, Aptitude & Reading Behavior; and one dependent variable *viz.* Operationalization of Design Thinking were considered in the scientific inquiry. The Diagnostic research design was followed while undertaking the study. Pretested interview schedule was used for primary data collection and personal interview of respondents. The appending binary logistic regression model as depicted in equation #1 was implement in the diagnosis of the scientific inquiry.

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i \quad \ldots\ldots (1)$$

Where, Y_i = Dependent variable, β_0 = y Intercept, β_1 = Population slope coefficient, X_i = Independent variables and ε_i = Random error component.

3. Results and Discussion

3.1 Independent Variables

3.1.1 Personal Characteristics of Respondents

It can be noted from Table 1 that the 'Age' of students ranged between 20-24 years in which majority of 39.29% were of 22 years, reflecting young productive graduates were being engaged in challenging the CC impacts in agriculture, a similar research reports had been commented by [4, 5]. Regarding 'Gender', equal percentage (50.00%) of male and female respondents had been randomly considered, displaying true non-bias sampling as per advocacy of FAO, [6] to close the gap between men and women. Similar considerations have been reported by [7, 8] in their researches. For OGPA, it was observed that 71.43% were in I division (7.000-7.999) while 28.57% were in I division with distinction (8.000 & above), depicting that the student-respondents were above average based on academic performance. Such similar findings had been reported by [9, 10].

Table 1: Personal Characteristic of Respondents

S. No.	Variables	Categories	Frequency	Percentage (%)
1.	Age	20 Years	2	7.14
		21 Years	6	21.43
		22 Years	11	39.29
		23 Years	5	17.86
		24 Years	4	14.29
2.	Gender	Male	14	50.00
		Female	14	50.00
3.	OGPA	Pass 5.000-5.999	0	0.00
		II Division (6.000-6.999)	0	0.00
		I Division(7.000-7.999)	20	71.43
		I Division with Distinction(8.000 & Above)	8	28.57

3.2 Psychological characteristic of respondents

By referring Table 2, it could be observed that 71.43% and 28.57% had high and low level of 'Competency on ICT Application', respectively. Similar findings were reported by [11, 12]. In case of 'Creative Problem Solving' equal number of respondents had high and low (50.00%) level of 'Creative Problem Solving'. The results contrasted with the findings of [13, 14]. With regard to 'Ability to Visualize Abstract Ideas', the 75.00% and 25.00% of respondents had high and low level 'Ability to Visualize Abstract Ideas', respectively. The finding is unparalleled with the research reports of [15, 16]. Regarding 'Memory Retention', 57.14% and 42.86% of respondents had high and low memory retention, respectively. This finding ratified with conclusion of [17]. As for 'Reading Behavior', equal percentage of (50.00%) of respondents had high and low level of 'Reading Behavior'. The results despaired with finding of [18]. For the case of 'Aptitude', 60.71% and 39.29% of respondents possessed high and low capability, respectively. The present finding was in agreement with [19], however contrasted with [20].

Table 2: Psychological Characteristics of Respondents

S. No.	Trait	Median	Category	Frequency	Percentage (%)
1.	Competency on ICT Application	27	Low	8	28.57
			High	20	71.43
2.	Creative Problem Solving	99.5	Low	14	50.00
			High	14	50.00
3.	Ability to Visualize Abstract Ideas	2	Low	7	25.00
			High	21	75.00
4.	Memory Retention	3.5	Low	12	42.86
			High	16	57.14
5.	Reading Behavior	67	Low	14	50.00
			High	14	50.00
6.	Aptitude	17	Low	11	39.29
			High	17	60.71

4. Dependent Variable

On perusal of Table 3, it can be observed that 54.00% and 46.00% of the respondents had high and low DT ability, respectively. The above finding was in contradiction with [21].

Table 3: Dependent Variable

S. No.	Trait	Median	Category	Frequency	Percentage (%)
1.	Operationalization of Design Thinking	22	Low	13	46.23
			High	15	53.57

5. Model on Design Thinking Ability in Climate Smart Agricultural Practices by Under-Graduate Agriculture Students of Central Agricultural University Imphal

5.1 Binary Logistic Regression Model on Design Thinking Ability in CSAPs by Under-Graduate Agriculture Students of CAU, Imphal

On explicating the binary logistic regression model on Design Thinking Ability in CSAPs by Under-Graduate Agriculture Students of CAU, Imphal, the following null and alternate hypotheses have been formulated.

H_0: There remains no interaction on outcome of being high or low 'Operationalization of DT' due to independent variables.

H_1: There is a significant interaction on outcome of being high or low 'Operationalization of DT' due to independent variables.

Values on statistic of model summary as depicted in Table 4, advocated that the binary logistic regression model on application of DT by Under-Graduate Students of CAU, Imphal was significant @ $p = 0.037$ with χ^2 value of 17.811, df = 18. The value of Akaike Information Criterion (AIC) = 40.862 hinted that the identified model could estimate correctly on the likelihood of being high and low 'Operationalization of DT' of the student-respondents with the probability of 0.024. The value of Bayesian Information Criterion (BIC) = 54.184 explained that the model complexity on estimating the outcome of dependent variable due to predictor variables by using sample data only with the probability of 0.018. The inquiry determined that the model, even though it was proved to be statistically significant, was not a virtuous model owing to the small sample size undertaken in the research.

Table 4: Summary of binary logistic regression model

Model Summary							
Model	**AIC**	**BIC**	**df**	**χ^2**	***p***	**Nagelkerke R^2**	**Cox & Snell R^2**
H_0	40.673	42.005	27				
H_1	40.862	54.184	18	17.811	0.037	0.629	0.471

The respective Cox & Snell R^2 and Nagelkerke R^2 values of 0.471 and 0.629 in the H_1 model, suggested that the proportion of variance on 'Operationalization of DT' associated with the independent variables in the study ranged from 47.10-62.90%.

Table 5: Coefficients of Statistic on Binary Logistic Regression Model

S. No.	Variable (along with Intercept)	Standard Error	Odds Ratio	z	*p*
1.	Intercept	15.455	3627.052	0.530	0.59
2.	Age	0.541	0.403	-1.681	0.09*
3.	OGPA	2.699	163.688	1.889	0.05**
4.	Competency on ICT Application'	0.399	1.049	0.121	0.90
5.	Creative Problem Solving	0.063	0.875	-2.106	0.03**
6.	Ability to Visualize Abstract Ideas	1.264	0.189	-1.317	0.18
7.	Memory Retention	0.290	0.862	-0.511	0.60
8.	Reading Behaviour	0.138	1.231	1.508	0.13
9.	Aptitude	0.089	1.003	0.038	0.97
10.	Gender (Female)	2.225	0.024	-1.683	0.09*

N.B.: (a) The high category of dependent variable-'Operationalization of Design Thinking' has been coded as reference category/point; (b) * & ** represent the significance @ 10% and 5% level of significance

An inference from the statistic values with respect to significant variables *viz.*, 'Age', 'OGPA' and 'Gender (Female)' at $p < 0.10$, $p \leq 0.05$ and $p < 0.10$, as exemplified in Table 5, shows that there was probability of 0.403 times of the student-respondents to have high category of 'Operationalization of Design Thinking' as the 'Age' of students increased with reference value of 20 years. It was observed that older student-respondents empathised the constraints faced by farmers on CSAPs better than younger ones, could transacted better DT ideas on improved CSAPs to farmers. Similarly, there was probability of 163.688 times of the student-respondents to have high category of 'Operationalization of Design Thinking' as the 'OGPA' of students increased with reference value of 5.000 OGPA. Keen observations on student-respondents during study could derived that students with higher OGPA were comparatively able to define agricultural problems, especially drudgery problems while handling agricultural implements, faced by farmers and farmwomen without difficulty. For the 'Creative Problem Solving' ability of student-respondents, there was high chance of 0.875 for the subjects to have high category of 'Operationalization of Design Thinking' as the 'Creative Problem Solving' ability of students increased with reference value of 25 scores. Administration of structured test to student-respondents could enlightened that high scorer students were ahead in understanding the dares on CSAPs being faced by farmers; they were better in strategy formulation for solving problems on identified CSAPs in scientific inquiry and learning interaction amongst them were fruitful as compared to low scorer on test pertaining to 'Creative Problem Solving' skill. Again, it could be narrated that for every single male student lifted toward high category of 'Operationalization of Design Thinking' there was probability of 0.024 times for the female student to be in high category of 'Operationalization of Design Thinking.' This finding had a backdrop that physical based DT on CSAPs were more prototyped and tested by male students-respondents when compared to female ones.

5.2 Performance Diagnostics of Identified Binary Logistic Regression Model

Analysing performance diagnostics on the identified model of the scientific inquiry by implying confusion matrix, as depicted in Table 6, unveiled that model correctly predicted the outcome by seventy five % (derivation of % proportion of diagonal values i.e. 0.321 +0.429 =0.750). With the sensitivity value of 0.800 in the model, as mentioned in Table 7, it could be inferred that the proportion of true positive on becoming high category on 'Operationalization of DT', was 80.00%. On the contrary, specificity value of 0.692 in the same model connoted that the proportion of true negative on becoming low category on 'Operationalization of DT.'

Table 6: Confusion Matrix of Binary Logistic Regression Model

	Predicted	
Observed	**0**	**1**
0	0.321	0.143
1	0.107	0.429

Table 7: Performance Metrics of Binary Logistic Regression Model

Criteria of Metrics	Values
Sensitivity	0.800
Specificity	0.692

Almost similar kind of regression models had been reported by [22, 23], dissimilar results reported by [24].

6. Conclusion and Recommendation

From the above binary logistic regression analysis, it could be concluded that 'Age', 'Gender', 'OGPA' and 'Creative Problem Solving Ability' were significant predictor variables of DT ability of students. Therefore the research recommended that the course curricula of B.Sc. (Agriculture) in CoAs of CAU, Imphal need to be focused on development of student 'Aptitude', 'Competency on ICT', 'Memory Retention', 'Ability to Visualize Abstract Ideas' and 'Reading Behavior' to enhance more on DT ability of the students.

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Competing Interests

The authors have declared no competing interest exist

Authors' Contributions

This work was carried out in collaboration between all the authors. Author 1 collected data, performed statistical analysis, wrote protocol and first draft the manuscript. Author 2 designed the study, assisted in analysis of the study and refined the manuscript. All authors read and approved the final manuscript.

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