*Research Article*

# A Detailed Study on Application of Mathematical Modeling Technology by Computer Sciences Research scholars in the selected Universities of Tamil Nadu State- Case Study Report

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**Abstract**

*The successful innovative process in any computer sciences research is based on effective implementation of mathematical modeling techniques. Recently, the Computer sciences research organizations in India and abroad ignored the importance of mathematical modeling techniques in their research process and gave no places in their curriculum. In the present study the investigator applied random sampling on research scholars and has tried to formulate eight hypotheses connecting the innovative and implementation variables and examined the relationships between innovative and implementation variables. By using regression analysis as well as by Scaffee's Post hoc test, the result demonstrated that innovative and implementation variables are significantly related. This implies that implementation of mathematical modeling technology in the computer sciences research was not successful. The investigator tried to identify the factors that would determine the successful implementation of mathematical modeling technology in the said research field. It is critically important that mathematically trained and technologically competent research experts should be appointed and utilized as resources in the computer research policy making bodies. Research organization with mathematical modeling facility should collaborate with those that lack those that lack them to provide all research activities and an opportunity to witness, learn from successful modeling related experiments.*

**Key Words:** computer sciences research scholars, mathematical modeling, compatibility, complexity, Spearman correlation, F-test T-test and Scaffee's Post hoc test.

## Introduction

Recently, the computer sciences research institutions worldwide ignored the importance of mathematical modeling technology practices among the research scholars and gave no place in their research curriculum. They ignored the critical input of mathematical modeling knowledge which is ultimately the key agents as regards conceptualizing and planning to make a breakthrough.

While ideally this radical departure from linear approach should have had a negative impact on computer sciences research practices and technical viability of research process, it nevertheless enjoyed significant success. The application of mathematical modeling techniques become major problem in today's computer science research field. The investigator is concerned with lack of mathematical modeling techniques and has tried to identify the factors in order to improve the application of mathematical modeling in computer sciences research practices.

The immediate commitment of any computer sciences research organization is that all the research scholars must develop, sharpen and deepen their understanding of mathematical modeling technique and its process. For this to occur a rigorous mathematical research curriculum must be recognized, taught and assessed in a problem solving environment.

The computer science research educational system in India particularly, the research organization is viewed as the driving force in development of our county (Singh and Misra, 2011). Mathematical modeling may have an impact on major industrial problem such as cost reduction and improvement of the device performance and efficiency (Paul and Jebaraj, 2014). Creation of knowledge based technological innovation and their commercialization through technology incubation would boot scholar's participation in knowledge creation and transfer process (Awasthi, Misra and Shahi, 2006).

By quickly building human resources with key knowledge and skill, the research organizations can help to develop responsiveness in the labor market (Burkman, 2010). Studies revealed that research organizations' culture and research practices play an important role in any research process. The main issues, which emerged, have been presented here in the form of following hypotheses.

## Hypotheses of the Study

The hypotheses of the study were stated as follows:-

Null Hypothesis - 1 There is no significant relationship between utilization with some selected independent variables compatibility, complexity.

Null Hypothesis - 2 There is no significant relationship between satisfaction with some selected independent variables compatibility and complexity.

Null Hypothesis - 3 There is no significant relationship between implementation with some selected independent variables compatibility, complexity.

Null Hypothesis - 4 There is no significant difference among different computer sciences scholars in utilization, satisfaction and implementation of mathematical modeling technology.

Null Hypothesis – 5 There is a significant difference between M.Phil., and Ph.D., computer sciences research scholars in utilization, satisfaction and implementation of mathematical modeling.

Null Hypothesis - 6 There is no significant difference among utilization, satisfaction and implementation of Mathematical modeling technology.

Null Hypothesis - 7 There is no difference in utilization of mathematical modeling by different computer sciences research scholars.

Null Hypothesis - 8 There is no difference in satisfaction of mathematical modeling by different computer science research scholars.

## Methodology

### Research design

The investigator applied diffusion theory in order to investigate the degree of adoption of mathematical modeling by computer research scholars in the selected universities of Tamil Nadu. Thus, Roger's (1995) diffusion theory becomes the best frame work for the present study. The diffusion theory emphasize five attributes namely, attitude, relative advantage, compatibility, complexity, and observability. The same characteristics were collected from the participants using appropriate research tool (Rao, 1993) and statistical analyses are used to draw the inference and conclusion.

### Variables study

The variables are important to state the nature of expected relationship in investigation planned and carried out by the research to gather evidence relevant to the two or more variables. In the present study independent and dependent variables were taken into consideration.

### Independent variables

Independent variables were manipulated by the investigator and in the present research study five independent innovative variables namely; attitude, relative advantage, compatibility, complexity and observability were taken for study.

### Dependent variables

Dependent variables were not manipulated. It was the cause-effect of independent variables on which the effect of the changes was observed and the values were hypothesized and in the present study the dependent variables selected were utilization, satisfaction and implementation variables.

### Control Variables

Sometimes uncontrollable variables that are not manipulated may have indirect influence upon dependent variables. These may have a significant impact on the outcome of the research study. The extraneous variable considered in the present study were research scholars' familiarity with mathematical modeling, whether they are presently using mathematical modeling or not, average time spent on mathematical modeling, stage they apply mathematical modeling, training undergone, usefulness of mathematical modeling, need of mathematical modeling in their research, reference habit of journals in mathematical modeling and finally, membership in any mathematical modeling association or user group.

### Sampling Procedure

The population for the study was computer research scholars, pursuing research degree in the two (Bharathiar Uuniversity and Periyar University) selected Universities in Tamil Nadu. A non-probability sampling or judgment sampling is followed to select 95 respondents. Two criteria were followed to select the respondents. These were that they must currently pursue the research degree (M. Phil. or Ph.D.) and they must belong to computer science, computer engineering or computer applications.

## Tools Used in the Study

For this study a questionnaire consisting of two tools was used.

1. Rao's(1993)instrumenton'Perceived Innovative Characteristics' (PIC) to measure innovative and implementation variables.
2. A tool (DAB) developed by the investigator to measure the demographic and background variables.

## Statistical techniques used in the study

The following statistical tools were used to analyze the collected data.

- Spearman's correlation coefficient is used to find out the relationship between variables.
- F-test is used to find out the significant difference among different types of variables.
- Scaffee's Post hoc test is used to find out where the difference occurs between the variables.
- T-test is used to find out the significant difference between different types of variables.

## Delimitation of the study

The following are the delimitations of the study:-

- The sampling was applied on research scholars from M.Phil. or Ph.D only. Research scholars from D.Sc. were not included.
- Due to limitations in time, money and administration the investigator focused on computer science discipline only. He could not concentrate on other disciplines.

However, maximum care was taken to improve the generality of results of the study to wider population of research scholars involving mathematical modeling practices.

## Summary of findings and conclusion

The following discussion is based on the results of this study and the implication of demographic and mathematical modeling background variables that offer insights in to the research context of implementing mathematical modeling in the selected universities.

## Major findings

The collected data were subjected to statistical analyses and the result obtained was interpreted. The following were the major findings:

## Demographical and situational profile

Majority of the research scholars are from Bharathiar University doing M.Phil. research in Computer science.

## Control variables

The investigator discusses the findings on control variables as follows.

## Modeling background knowledge

The data analysis showed that the research scholars are not familiar with mathematical modeling. Majority of the research scholars spend less than one hour per day working with mathematical modeling which implies poor modeling practice among research scholars. The study discovers majority of the research scholars using mathematical modeling at present. Among them a vast majority of 92 percent, combined their use of mathematical modeling to 'aid instruction', 'access research' information or 'aid research administration'.

They combined their purpose for using Mathematical modeling to access the research information, to draw research conclusion and to aid the exiting fact. Majority of the research scholars agreed that the training in mathematical modeling was either very useful or useful. The study reveals that the research scholars enrolled in modeling training program, majority was interested in the advanced mathematical modeling than basic modeling literacy.

The research scholars were eagerly expecting further training in mathematical modeling. They expect frequent modeling training program. Reading habit among the research scholars should be encouraged. Only 2 percentages of the research scholars refer more journals on Mathematical modeling. The study shows that majority of the research scholars belong to none of the mathematical modeling association or user group reflects a bad picture of membership by the respondents.

## Innovative variables

The investigator studied five innovative variables and gives the result here.

## Attitude

Majority of the research scholars strongly believed that mathematical modeling would replace traditional research process and it would make the work of research scholars less tedious. They perceived research scholars today could not escape the influence of mathematical modeling. Also they agreed that mathematical modeling would bring about a better way of life for average research scholars. They strongly hoped that mathematical modeling was a potential research tool and would create in-depth knowledge. The research scholars feared that mathematical modeling would increase our dependence on western countries and dehumanize the research community as a whole.

A vast majority of the respondents understood that mathematical modeling would bridge the educational gap between developed and developing countries. They positively viewed mathematical modeling and thought it was suitable for developing countries like India, bringing to a bright era with unlimited possibilities for modeling applications. Nearly 1/3rd of the respondents agreed they had fear of using mathematical modeling. They accepted the fact that mathematical modeling was beyond the understanding of the ordinary research scholars. The data showed research scholars need to be assured that mathematical modeling do not pose a threat to their research skills.

### Relative advantage

Research scholars had a positive perception of the relative advantage of mathematical modeling compared to traditional method of research instruction. They perceived that mathematical modeling could enable quicker access to information and helped to overcome administrative delays. They believed that mathematical computing would be worth the investment when all the universities in the country begin to use mathematical modeling techniques.

### Compatibility

Compatibility produced most significant results. Majority agreed mathematical modeling technology did not fit well in to their curriculum goals and they had relied on books and other printed materials. They agreed that mathematical modeling would become an essential research tool as it meets their research information needs. The respondents wished they were in need of a tool like mathematical modeling in their research educational system. Majority of the respondents expressed the view that scarcity of resources in universities does not permit expensive services like mathematical modeling.

### Complexity

The study showed that research scholars faced difficulty in understanding technical function of mathematical modeling and need to refer hand book frequently to understand the modeling operations. They deeply felt mathematical modeling complicated simple research administrative function in their research process. Majority of the respondents did not think mathematical modeling enhanced their job as a researcher. Mathematical modeling background of the research scholars was very poor. They were unable to respond to their perceived complexity of mathematical modeling. The result did not show a relationship between complexity and adoption/ implementation variables.

### Observability

The research study reveals that nearly half of the respondents were unaware of mathematical modeling at research work. They had never seen modeling being used as a research tool. Majority of the research scholars found no difficulty in demonstrating the research uses of mathematical modeling.

### Implementation variables

In order to measure the degree of adoption of mathematical modeling by research scholars the investigator selected two implementation variables namely, utilization and satisfaction variables and the result is as follows:-

### Research scholars' satisfaction

The analysis of the research study showed that majority of research scholars felt that access to online information about mathematical modeling within the country was generally not good. Though they accepted access to online information about mathematical modeling worldwide was generally good. 30 percentage of the respondents believed that online information about mathematical modeling as and when required at the national level was good. Majority agreed that at the international level it was good. They perceived mathematical modeling was reliable, accurate and meet their research information needs. Nearly 1/3rd of the research scholars accepted they were able to send online information about modeling at the national level as and when required.

They were able to respond satisfactorily that mathematical modeling was current and relevant. They strongly expressed mathematical modeling was useful research tool, helpful in increasing educational opportunities and to interact. They agreed mathematical modeling facilitates group research learning, overcomes time and place restrictions. It helps in research analysis and result outcome.

The data analysis indicated that majority of the research scholars frequently used mathematical modeling to access innovative information as well as for research instructional purposes. The study also revealed the research scholars used mathematical modeling frequently to aid research administration and to make research more accessible. Majority of the respondents also specified they used mathematical modeling to connect their discipline to mathematics in order to extract abstract outcome.

### Testing of Hypotheses

In order to test the formulated hypotheses, the same were stated in the null form. The testing of the null hypotheses are described as follows:-
Null Hypothesis – 1: There is no significant relationship between utilization with some selected independent variables attitude, relative advantages, compatibility, complexity, and observability.

**Table-1: Relationship between utilization with some selected independent variables**

| Dependent variable | Independent variables | Correlation value (r) | Significant value |
|---|---|---|---|
| Utilization | Attitude | 0.529 | P>0.05 |
| | Relative Advantages | 0.432 | P>0.05 |
| | Compatibility | 0.612 | P>0.05 |
| | Complexity | -0.331 | P>0.05 |
| | Observability | 0.466 | P>0.05 |

Table –1 shows that the Spearman's correlation coefficient for attitude, relative advantages, compatibility, observability with utilization are 0.529, 0.432, 0.612 and 0.466, respectively. It is significant at 0.05 level of significance. It is found that there is a positive significant relationship between utilization with attitude, relative advantages, compatibility and observability. And also the above table shows that the Spearman's correlation coefficient for complexity of mathematical modeling as - 0.331. It is significant at 0.05 level. It is also found that there is a negative significant relationship between utilization with complexity. Hence, the null hypothesis is rejected at 0.05 level of significance. This inference points out that if the attitude of the research scholars towards mathematical modeling increases, then the utilization increases, if the relative advantages increases, then the utilization increases, if the compatibility increases, then the utilization increases, if the observability increases, then the utilization increases, if the complexity increases, then the utilization of decreases and vice versa.

Null hypothesis - 2: There is no significant relationship between satisfaction with some selected independent variables attitude, relative advantages, compatibility, complexity and observability.

**Table- 2: Relationships between satisfactions with some selected independent variables**

| Dependent variable | Independent variables | Correlation value (r) | Significant value |
|---|---|---|---|
| Satisfaction | Attitude | 0.496 | P>0.05 |
| | Relative Advantages | 0.423 | P>0.05 |
| | Compatibility | 0.563 | P>0.05 |
| | Complexity | -0.452 | P>0.05 |
| | Observability | 0.396 | P>0.05 |

Table –2 shows that the Spearman's correlation coefficient for attitude, relative advantages, compatibility and observability with satisfaction are 0.496, 0.423, 0.563, and 0.396, respectively. It is significant at 0.05 value. It is found that there is a positive significant relationship between satisfaction with attitude, relative advantages, compatibility and observability. Also, the above table shows that the Spearman's correlation coefficient for complexity of mathematical modeling as -0.452. It is significant at 0.05. It is also found that there is a negative significant relationship between satisfactions with complexity. Hence the null hypothesis is rejected at 0.05 level of significance. This inference points out that if the attitude of the research scholars towards mathematical modeling increases, then the satisfaction of mathematical modeling increases, if the relative advantages increases, then the satisfaction increases, if the compatibility increases, then the satisfaction increases, if the observability increases, then the satisfaction increases, if the complexity increases, then the satisfaction decreases and vice versa.

Null hypothesis –3: There is no significant relationship between implementation with some selected independent variables attitude, relative advantages, compatibility, complexity and observability.

**Table -3: Relationships between implementation with some selected independent variables**

| Dependent variable | Independent variables | Correlation value (r) | Significant value |
|---|---|---|---|
| Implementation | Attitude | 0.421 | P>0.05 |
| | Relative Advantages | 0.603 | P>0.05 |
| | Compatibility | 0.362 | P>0.05 |
| | Complexity | -0.296 | P>0.05 |
| | Observability | 0.391 | P>0.05 |

Table– 3 shows that the Spearman's correlation coefficient for attitude, relative advantages, compatibility and observability with implementation are 0.421, 0.603, 0.362, and 0.391, respectively. It is significant at 0.05 value. It is found that there is a positive significant relationship between implementation with attitude, relative advantages, compatibility and observability.

Table-3 also shows that the Spearman's correlation coefficient for complexity of mathematical modeling as-0.296. It is significant at 0.05. It is also found that there is a negative significant relationship between implementation with complexity. Hence, the null hypothesis is rejected at 0.05 level of significance. This inference points out thatiftheattitudeoftheresearchscholars towards mathematical modeling increases, then the implementation of mathematical modeling increases, if the relative advantages increases, then the implementation increases, if the compatibility increases, then the implementation of mathematical modeling increases, if the observability increases, then the implementation increases, if the complexity increases, then the implementation decreases and vice versa.

Null hypothesis – 4: There is no significant difference among different disciplined scholars in utilization, satisfaction and implementation of mathematical modeling.

**Table-4: Differences among different disciplined scholars**

| Groups | Source & variance | Sum of squares | Degrees of freedom | Mean square | F | Signifi-cance |
|---|---|---|---|---|---|---|
| Utilization | Between | 96.236 | 2 | 11.23 | 14.123 | P<0.05 |
| | Within | 1256.25 | 1512 | 20.31 | | |
| | Total | 1352.49 | 1514 | | | |
| Satisfaction | Between | 163.21 | 2 | 23.02 | 13.456 | P<0.05 |
| | Within | 4145.23 | 1512 | 24.32 | | |
| | Total | 4308.44 | 1514 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Implementation | Between | 107.21 | 2 | 9.32 | 14.632 | P<0.05 |
| | Within | 2639.2 | 1512 | 12.03 | | |
| | Total | 2746.41 | 1514 | | | |

Table- 4 shows that the calculated F value of utilization, satisfaction and implementation of mathematical model are 14.123, 13.456, and 14.632 respectively, which are greater than the tabulated F value 2.99 for df (2, 1512). The null hypothesis is rejected at 0.05 level of significance. Hence, there is a significant difference among science, arts, and management scholars in utilization, satisfaction and implementation of mathematical modeling.

Null hypothesis – 5: There is a significant difference between M.Phil and Ph.D scholars in utilization, satisfaction and implementation of mathematical modeling.

**Table-5: Mean difference between M.Phil and Ph.D computer research scholars**

| Dependent Variables | M.Phil Scholars | | | Ph.D Scholars | | | df | t-value | Significance |
|---|---|---|---|---|---|---|---|---|---|
| | N1 | M1 | SD1 | N2 | M2 | SD2 | | | |
| Utilization | 1015 | 17.231 | 1.23 | 500 | 20.311 | 1.29 | 1513 | 45.09 | P<0.05 |
| Satisfaction | 1015 | 52.031 | 2.09 | 500 | 56.227 | 2.63 | 1513 | 33.65 | P<0.05 |
| Implementation | 1015 | 32.125 | 2.11 | 500 | 38.002 | 2.88 | 1513 | 44.97 | P<0.05 |

Table – 5 shows that, the calculated't' value for utilization, satisfaction and implementation are 45.09, 33.65, and 44.97, respectively and those are greater than the tabulated t-value for df (1513) is 1.96. The null hypothesis is rejected at 0.05 level of significance. Hence there is a significant difference between M.Phil and Ph.D scholars in utilization, satisfaction and implementation of mathematical modeling. And also it is observed in the table that, the Ph.D scholars mean scores are higher than the M.Phil scholars mean score. It shows that the utilization, satisfaction, and implementation of Mathematical modeling is more for Ph.D scholars than M.Phil scholars.

Null hypothesis – 6: There is no significant difference among utilisation, satisfaction and implementation of Mathematical modeling.

**Table-6: Difference among utilization, satisfaction and implementation**

| Source and variance | Sum of squares | Degrees of freedom | Mean square | F | Significance |
|---|---|---|---|---|---|
| Between | 124.033 | 2 | 23.212 | 1.236 | P<0.05 |
| Within | 4238.002 | 1512 | 423.021 | | |
| Total | 4362.035 | 1514 | | | |

Table -6 shows that the calculated F value is 1.236, which is less than the tabulated F value 2.99 for df (2, 1512). The null hypothesis is accepted at 0.05 level of significance. It shows that, there is no significant difference among utilization, satisfaction and implementation of mathematical modeling.

**Scaffe's Post hoc test**

Null hypothesis – 7: There is no difference in utilization of mathematical modeling by different computer science research scholars.

Scaffee's Post hoc test is used to find out where the difference occurs between utilization of computer science research scholars. An attempt has been made to analyze it.

**Table-7: Post hoc test for utilization of different computer science research scholars**

| Computer Engineering | Computer Science | Computer application | I-J |
|---|---|---|---|
| 14.216 | 12.089 | | 2.127 |
| 14.216 | | 11.237 | 2.979 |
| | 12.089 | 11.237 | 0.852 |

From table-7 Scaffee's post hoc test shows that utilization of mathematical modeling for Computer Engineering scholars are higher than the students of Computer Science and Computer application, Utilization of mathematical modeling for computer science scholars are higher than the Computer application research scholars.

Null hypothesis – 8: There is no difference in satisfaction of mathematical modeling by different computer science research scholars.

Scaffee's post hoc test is used to find out where the difference occurs between satisfactions of different engineering students. An attempt has been made to analyze it.

**Table-8: Post hoc test for utilization of different computer science research scholars**

| Computer Engineering | Computer Science | Computer application | I-J |
|---|---|---|---|
| 14.216 | 36.265 | | 6.511 |

| | | | |
|---|---|---|---|
| 14.216 | | 32.117 | 8.759 |
| | 34.265 | 32.118 | 1.048 |

From table-8 Scaffe's post hoc test shows that satisfaction of mathematical modeling for Computer Engineering research scholars are higher than the students of computer science and computer application research scholars satisfaction of mathematical modeling for computer science are higher than the computer application research scholars.

## Analysis on priority to constructs

### Method of ranking to constructs

In order to rank the construct from the most positive to least, average mean scores are calculated. These are obtained by dividing the mean scores of constructs by the number of items in each construct or scale. Then based on the earlier assertion that lower scores indicate more positive response and higher scores indicate less positive responses, the average mean scores are ranked. The construct with the lowest mean score received the 'first' rank. While the highest mean score received 'last' rank.

### Description of the calculation table- 9

Mean responses to the constructs of (a) Attitude ; (b) Perception ; (c) Satisfaction ; (d) Satisfaction of mathematical modeling by research scholars, as well as the range of scale in each construct is also presented in the tabular form. The scores for 'strongly agree' represent the minimum of the scale, while those for 'strongly disagree' represent the maximum. Lower score indicate more positive response and vice versa. The computation is given in table 9.

**Table-9: Distribution of computer research scholars based on priority to constructs**

| S. No. | Mathematical modeling as (Constructs) | No. of items per scale | Mean score of constructs | Range of scales | | Average mean score | Rank |
|---|---|---|---|---|---|---|---|
| | | | | Strongly agree | Strongly disagree | | |
| 1 | Potential Research tool | 5 | 12.89 | 5 | 25 | 2.58 | Fifth |
| 2 | Threat | 3 | 10.61 | 3 | 15 | 3.53 | Fourteenth |
| 3 | Employment tool | 2 | 4.42 | 2 | 10 | 2.21 | First |
| 4 | Relative advantage | 5 | 13.11 | 5 | 25 | 2.62 | Sixth |
| 5 | Research instruction | 3 | 8.28 | 3 | 15 | 2.76 | Ninth |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 | Curriculum needs | 3 | 7.37 | 3 | 15 | 2.45 | Second |
| 7 | Complexity | 4 | 10.6 | 5 | 20 | 2.65 | Sev-enth |
| 8 | Observabil-ity | 3 | 8.36 | 3 | 15 | 2.78 | Tenth |
| 9 | Research information tool | 4 | 9.97 | 5 | 20 | 2.49 | Fourth |
| 10 | Reliability accuracy | 5 | 14.26 | 5 | 25 | 2.85 | Elev-enth |
| 11 | Research Learning tool | 5 | 14.52 | 5 | 25 | 2.90 | Twelfth |
| 12 | Networking tool | 2 | 6 | 2 | 10 | 3.00 | Thir-teenth |
| 13 | Research administra-tive tool | 3 | 7.43 | 4 | 20 | 2.47 | Third |
| 14 | Research Education & Networking | 3 | 8.14 | 3 | 15 | 2.71 | Eighth |

The collected data were analyzed based on the objectives and hypotheses formulated for the study and through analysis of result and interpretation.

## Recommendations

Mathematical modeling training for research scholars should emphasize the individual and national benefits of mathematical modeling literacy in order to retain a positive awareness. The curricula of education should address issues related to rapid changes in modeling technology, new demands of the research work force and the need for research scholars to be technologically competent. The importance of compatibility in the satisfaction and adoption process underscores the need for strategic planning in mathematical modeling training, designed to accomplish specific curriculum objectives. The literature notes that making modeling compatible with research scholar's tasks will boost its implementation by specifying its role more precisely.

Mathematical modeling practice should be configured to accomplish specific tasks such as, drawing conclusion, creative, innovative, logical thinking, abstract thinking, drawing and inter connections etc. It is important that mathematical modeling training program should emphasize the relative advantage of mathematical modeling to traditional methods of research instruction and research education as a whole. Additional exposure to mathematical modeling is recommended for research scholars. Research scholars also must be provided with adequate opportunities to practice with modeling following their training programs.

Universities with mathematical modeling facilities should collaborate with those that lack them. So that, all research scholars get an opportunity to witness, learn from successful modeling related experiments. The curriculum should make guidelines for the effective use of modeling technology. The research educators and scholars must understand the direction of innovative scientific progress and can update their mathematical modeling technology training programs to meet emerging industrial need. It is critically important that mathematically trained and technologically competent research experts should be utilized as resources in the research decision making bodies.

## Suggestions for further research

Further, this research can be extended to establish the following statements:-

In the present study, diffusion theory is used to investigate the adoption of mathematical modeling by the research scholars. It is suggested that the same theory can be applied in other innovative technology introduced recently and the effectiveness of adoption may be examined against the conventional method. Similar studies should be undertaken in other research areas such as, medicine or sciences etc. Diffusion approach may be undertaken either at master degree level or D.Sc. level.

## Conclusion

In keeping with the philosophy of participation in developing initiative, researcher participation in the planning process is the key ensuring the successful implementation of mathematical modeling technology in the universities. Strong commitment from research scholars to embrace modeling technology is essential in attaining the country's goals for mathematical modeling use. Active involvement of research scholars who are users and non-users is a practical means of moving the initiative forward. A cadre of research scholars motivated by the potential of Mathematical modeling can ignite the interest of others to become users.

Finally, the involvement and leadership of research scholars as well as policy makers facilitate a 'buy-in' element that will guarantee the successful implementation of mathematical modeling throughout the research education.

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