Concept Understanding … Making it Easy

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Theme	EVALUATION
Subthemes covered	1. EVALUATION OF CONCEPTUAL UNDERSTANDING 2. EVALUATION OF PROBLEM SOLVING ABILITY

Abstract

Evaluation needs to focus on the level of students' understanding of concepts behind the topics being taught. This particularly holds good for Science, Technology, Engineering and Mathematics (STEM) subjects wherein unless the concept is understood, applying the learning to day-to-day life situations becomes practically not possible.

The present research paper aims at discussing the effectiveness of demonstrative methods in teaching on the level of conceptual understanding by students and impact the same has on their problem solving ability, applications and also communication skills. Demonstrative methods make use of means such as computer based animated power point presentations, objects from day-to-day use, audio/video clips, etc.

For the purpose of this research, "Permutations and Combinations" topic from Mathematics syllabus was selected particularly because of the concept involved therein are abstract. A group of students therefore were taught the topic using demonstrative teaching methods and animated power point presentation. Their level of understanding was evaluated during the pre-teaching and post-teaching phase to draw inferences and prove the hypothesis.

KEYWORDS: Demonstrative Teaching, Evaluation, Concept, Mathematics made easy, Problem Solving, Maths, Permutations and Combinations, Conceptual Understanding

Introduction

Every mathematics teacher faces several challenges while teaching such as generation gap with students, discipline, their interest levels, varied acumen etc. The “system” that the teachers are part of, many times forces them to overlook these challenges and move on rather than experiment. That’s where teachers lose out on joy and excitement in teaching and overall subject understanding by students suffer.

Generally it gets considered that Evaluation is nothing but conducting tests, analysing scores and drawing out a merit list. However, Evaluation is an important aspect of entire education system and must be done at every stage of teaching-learning process and that too on various subthemes.

In the absence of overall and comprehensive evaluation, correctly measuring teaching and learning effectiveness will not be possible. Understanding of concepts, their applications and abilities to make use of the learning to solve day-to-day problems are key outcome of education, particularly for the subjects such as Science and Mathematics.

For the success of teaching-learning activities, Teachers must carefully and sincerely evaluate students throughout the educational process and be innovative in terms of tweaking teaching methods. Making use of demonstrative teaching methods and encouraging them to experiment is definitely a key to make the Teaching & Learning Mathematics a joyful experience.

Objectives

Mathematics normally gets considered to be a “dry” and “heavy” subject. However, Mathematics is one of the most important subjects that every student must learn. At end of the day, Mathematics finds its application in practically every facet of our day-to-day life. Concept understanding is extremely important and problem solving becomes difficult if the concept is not understood correctly.

Therefore Teaching & Learning Mathematics must be made a joyful experience. Use of demonstrative techniques in teaching and use of properties for self learning by students were thought to be of great value here.

A detailed study in form of this project was therefore planned and executed with the key objective of studying the effectiveness of demonstrative methods in teaching on -

1. The level of conceptual understanding of the topic.
2. The improvement in problem solving ability of students
3. The improvement in ability to apply the learning made to day-to-day life situations.

Research Methodology and Tools & Technique

The student samples were split into two groups.

a. Control Group – This group consisted of students that were exposed to normal conditions, meaning those students who are taught the selected topic using conventional teaching methods.
b. Experiment Group – This group consisted of students that were under training. These students were taught using the innovative, demonstrative teaching techniques for determining the impact of newer teaching methods on students.

Both the groups were approximately of size 20 each and while selecting the samples, care was taken to select students of different IQ level with benchmark used as their Std. X marks in Mathematics.

Further, the Research Project proceeded with the following steps.

1. A topic "Permutations and Combinations" was selected from Mathematics syllabus of Std. XI. This specific topic was selected as the same is concept driven.
2. A pilot test was conducted for both "Control" as well as "Experiment" group and the scores of the students were recorded. The test questions were carefully set in order to gauge students' understanding of concept behind the selected topic. Refer Annexure I
3. The topic "Permutations & Combinations" was then taught again to the students from "Experiment" group using newer and unconventional techniques such as –
    a. Making use of animated power point presentations. By way of animations, base concept behind "Permutations & Combinations" could be explained in a simpler manner. Refer Annexure IV.
    b. Discussing day-to-day and real life examples such as arrangements of people for a photograph, making words, numbers, selection of people in a committee, choosing cards from a well shuffled pack of cards, etc.
    c. Taking clues from the day-to-day life situations such as "opening of number lock", "constructing vehicle number plates", "setting PINs for Mobile phones", etc and encouraging students to experiment on their own using the available properties and experience the basis behind the concepts & terminologies
    d. Solving several examples for the students & by the students.
4. Final test was conducted for both "Control" as well as "Experiment" group in order to re-assess students' level of concept understanding. Refer Annexure II
5. Additionally, another final test with questions targeted towards the applications of the concepts in permutation and combination was conducted for "Experiment" group only to judge the impact on their abilities to apply concepts to day-to-day life situations. Refer Annexure III
6. The scores of the two final tests were then compared with the scores of the pilot test and analysed on different parameters using statistical techniques to draw out conclusions.

Data analysis and interpretation

The Research data captured during the project and calculation of "t" value is as under –

Control Group

Considering that the students from the control group did not receive special teaching with demonstrative methods, we can write the null hypothesis as :

$H_0 : \mu_1 = \mu_2$ i.e. $\overline{D} = 0$ i.e. There was no effect on the mean score of the students.

$H_a : \mu_1 \neq \mu_2$ i.e. There was an effect due to maturity that is perhaps gained with time.

Where μ_1 and μ_2 are mean scores of the students for the pilot test and the final test respectively.

Student #	Pilot Test Score (X)	Final Test # 1 Score (Y)	di = (X - Y)	di^2
1	0	0	0	0
2	6	7	-1	1
3	7	5	2	4
4	6	6	0	0
5	3	3	0	0
6	4	5	-1	1
7	2	7	-5	25
8	6	7	-1	1
9	6	4	2	4
10	6	9	-3	9
11	7	6	1	1
12	5	6	-1	1
13	6	7	-1	1
14	4	2	2	4
15	5	7	-2	4
16	7	6	1	1
17	3	6	-3	9
18	6	9	-3	9
19	6	5	1	1
20	9	8	1	1
		∑	**-11**	**77**

$$\bar{D} = \frac{\sum d_i}{n} = \frac{-11}{20} = -0.55$$

$$\sigma_d = \sqrt{\frac{\sum d_i^2 - (\bar{D})^2 n}{n-1}}$$ = 1.9324 (After substituting values)

$$t = \frac{\bar{D} - 0}{\frac{\sigma_d}{\sqrt{n}}} =$$ – 1.2729 (After substituting values)

For significant level of α = 0.05 and 19 degrees of freedom, "t" critical value = – 1.729 and observed value of "t" = – 1.2729 as calculated above

Since │- 1.2729 │ < │- 1.729 │ we accept H_0 and conclude that the difference in scores in the two tests of the control group is insignificant.

Experiment Group

Considering that the students from the experiment group received special teaching with demonstrative methods, we can write the null hypothesis as :

$H_0 : \mu_1 = \mu_2$ i.e. $\bar{D} = 0$ i.e. Demonstrative teaching has no effect on the mean scores of the students

$H_a : \mu_1 < \mu_2$ i.e. The demonstrative teaching has been effective.

Where μ_1 and μ_2 are mean scores of the students for the pilot test and the final test # 1 and 2 respectively.

Student #	Pilot Test Score (X)	Final Test # 1 Score (Y)	Final Test # 2 Score (Z)	Di = (X - Y)	di = (X - Z)	Di^2	di^2
1	1	12	5	-11	-4	121	16
2	9	17	10	-8	-1	64	1
3	2	25	12	-23	-10	529	100
4	1	19	7	-18	-6	324	36
5	4	18	6	-14	-2	196	4
6	12	21	17	-9	-5	81	25
7	16	25	18	-9	-2	81	4
8	12	24	3	-12	9	144	81
9	3	13	6	-10	-3	100	9
10	8	22	8	-14	0	196	0
11	0	9	1	-9	-1	81	1
12	3	5	2	-2	1	4	1
13	20	25	24	-5	-4	25	16
14	1	6	4	-5	-3	25	9
15	1	11	5	-10	-4	100	16
16	5	20	16	-15	-11	225	121
17	7	19	5	-12	2	144	4
18	12	24	17	-12	-5	144	25
19	21	25	13	-4	8	16	64
20	3	13	4	-10	-1	100	1
21	3	5	3	-2	0	4	0
			∑	**-214**	**-42**	**2704**	**534**

Final Test # 1	Final Test # 2
$\overline{D} = \frac{\sum D_i}{n} = \frac{-214}{21} = -10.19$	$\overline{D} = \frac{\sum d_i}{n} = \frac{-42}{21} = -2$
$\sigma_d = \sqrt{\frac{\sum D_i^2 - (\overline{D})^2 n}{n-1}}$ = 5.1148 (After substituting values)	$\sigma_d = \sqrt{\frac{\sum d_i^2 - (\overline{D})^2 n}{n-1}}$ = 4.7434 (After substituting values)
$t = \frac{\overline{D} - 0}{\frac{\sigma_d}{\sqrt{n}}} = -9.1297$ (After substituting values)	$t = \frac{\overline{D} - 0}{\frac{\sigma_d}{\sqrt{n}}} = -1.9322$ (After substituting values)

For significant level of α = 0.05 and 20 degrees of freedom, "t" critical value (Final Test # 1) = – 1.725 and observed value of "t" = – 9.1297 as calculated above.

Since $\left|-\ 9.1297\ \right| > \left|-\ 1.725\ \right|$ we reject H_0 and accept H_a to conclude that the difference in scores in the two tests of the Experiment group is significant and hence Demonstrative teaching has been a success.

For significant level of α = 0.05 and 20 degrees of freedom, "t" critical value (Final Test # 2) = – 1.725 and observed value of "t" = – 1.9322 as calculated above.

Since $\left|-\ 1.9322\ \right| > \left|-\ 1.725\ \right|$ we reject H_0 and accept H_a to conclude that the difference in scores in the two tests of the Experiment group is significant and hence Demonstrative teaching has been a success.

Comparison of performance of Control Group and Experiment Group

Both Control group and Experiment group consisted of students that underwent the Pilot test and Final Test # 1. The comparison of scores secured by students from Control and Experiment group in the final test # 1 is important from the perspective of proving effectiveness of Demonstrative methods in teaching.

Considering that the students from the control group did not receive any special training while those from experiment group received special teaching with demonstrative methods, we can write the null hypothesis as :

$H_0 : \mu_1 = \mu_2$ i.e. There was no difference in the mean scores for students from Control and Experiment group.

$H_a : \mu_1 < \mu_2$ i.e. The demonstrative teaching has been effective.

Where μ_1 and μ_2 are mean of scores secured by students from Control and Experiment group in the final test # 1.

Control Group			Experiment Group		
Student #	**Final Test # 1 Score (X_1)**	**X_1^2**	**Student #**	**Final Test # 1 Score (X_2)**	**X_2^2**
1	0	0	1	12	144
2	7	49	2	17	289
3	5	25	3	25	625
4	6	36	4	19	361
5	3	9	5	18	324
6	5	25	6	21	441
7	7	49	7	25	625
8	7	49	8	24	576
9	4	16	9	13	169
10	9	81	10	22	484
11	6	36	11	9	81
12	6	36	12	5	25
13	7	49	13	25	625
14	2	4	14	6	36
15	7	49	15	11	121
16	6	36	16	20	400
17	6	36	17	19	361
18	9	81	18	24	576
19	5	25	19	25	625
20	8	64	20	13	169
			21	5	25
∑	**115**	**755**	∑	**358**	**7082**

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{\sum(X_1 - \bar{X}_1)^2 + \sum(X_2 - \bar{X}_2)^2}{n_1 + n_2 - 2}} \times \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} = - 5.53$$

For significant level of α = 0.05 and 39 degrees of freedom, “t” critical value (Final Test # 1) = 2.024 and observed value of “t” = – 5.53 as calculated above.

Since $|-5.53| > |2.024|$ we reject H_0 and accept H_a to conclude that the difference in scores achieved by students from Experiment group is significant and thus there is a positive effect on the mean scores proving effectiveness of demonstrative methods in teaching.

Conclusions

1. The Demonstrative methods in teaching have a substantial positive effect on students' level of conceptual understanding of the topic.
2. The Demonstrative methods also improved the problem solving capabilities of the students and apply the learning made to day-to-day life situations.
3. The effect on ability to solve difficult problems however was not substantially significant. Though the students could solve routine and general level problems, problems with higher complexity still remained to be a challenge for them.

Icing on the cake*:* – Apart from the objectives of the research and selected subthemes through a live example it also got proved that demonstrative teaching methods have positive impact on students' communication skills. The Experiment group that was taught using the demonstrative teaching methods were found to have improved abilities to express. As part of the routine initiatives at the college, on 28th July 2018, a competition to present any topic in mathematics was held. Total 8 teams participated and the winner team consisted of students from the Experiment group of this research. The external judge for the competition event explicitly appreciated the way the winning team could express and explain the concept underlying the selected topic.

Thus, demonstrative methods in teaching has positive impact on –

- ➢ The level of conceptual understanding of the topic.
- ➢ The improvement in problem solving ability of students.
- ➢ The improvement in ability to apply the learning made to day-to-day life situations.
- ➢ Communication capabilities of students

Scope for Future Work

In order to test the hypothesis further for the identified subthemes, the following variations can be implemented.

1. Repeating the research on different topics where concept understanding and applications are involved.
2. Selection of bigger sample size for Control and Experiment group
3. Selection of Control and Experiment group members based on different parameters such as gender, IQ level, Family background, etc
4. Exploring additional demonstrative teaching methods
5. Exploring ways to improve students' ability to solve difficult problems.

Acknowledgements

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2. The expert trainers Prof. Sudhir Panse, Shri. Hemant Lagavankar and Dr. Vivek Patkar for delivering valuable lectures during the workshop and making me aware of importance of evaluation in the whole education process.
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4. Principal Dr. (Mrs.) Ancy Jose and my colleagues at B.S.G.D. Junior College of Commerce, Arts and Science for their facilitation, support and encouragement.
5. My family and friends for helping me directly or indirectly during the research phase and also while compiling this research project document within the available time frame.

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Annexures

I. Pilot Test Paper
II. Final Test Paper # 1
III. Final Test Paper # 2
IV. PowerPoint Presentation used for teaching the Experiment group
V. Research Schedule

Annexure I
Pilot Test Paper

DATE: 23/06/2018 **DURATION: 45 mins.**

Test Paper – Permutations & Combinations

NAME:

CLASS: **DIVISION:** **ROLL NO.** **CONTACT NO.**

Solve the following questions.

1. Find the number of 4 letter words, with or without meaning, which can be formed out of the letters of the word BOLT, where repetition of letters is not allowed.
2. If $\frac{1}{8!} + \frac{1}{9!} = \frac{x}{10!}$, find 'x'.
3. How many 4 different digit numbers can be formed by using the digits 1 to 9?
4. Find 'r', if $5 ({}^{4}P_{r}) = 6 ({}^{5}P_{r-1})$
5. If ${}^{n}C_{9} = {}^{n}C_{8}$, find ${}^{n}C_{17}$
6. In how many ways can a team of 3 boys and 3 girls be selected from 5 boys and 4 girls?
7. A group consists of 4 girls and 7 boys, in how many ways can a team of 5 members be selected if the team has at least one boy and one girl?
8. In how many ways the letters of the word ROOT can be arranged?
9. In how many ways can 5 girls and 3 boys be seated in a row for a photograph so that no two boys are together?
10. How many words, with or without meaning, each of 3 vowels and 2 consonants can be formed from the letters of the word INVOLUTE?

Annexure II
Final Test Paper # 1

DATE: 18/07/2018 **DURATION: 45 mins**

Test Paper – Permutations & Combinations

NAME:

CLASS: DIVISION: ROLL NO. CONTACT NO.

Solve the following questions.

1. If $\frac{1}{5!} + \frac{1}{6!} = \frac{x}{7!}$, find 'x'.
2. Find 'r', if ${}^{5}P_{r} = 2\,({}^{6}P_{r-1})$
3. Find 'n' if ${}^{2n}C_{3} : {}^{n}C_{3} = 12 : 1$
4. Find the number of signals generated if each signal requires the use of 2 flags, one below the other, out of 5 flags of different colours.
5. How many 4 digit numbers are there with no digit repeated?
6. Find the number of arrangements of the letters of the word "DAUGHTER". Also find number of arrangements such that no two vowels are together.
7. Find the number of arrangements of the letters of the word "INDEPENDENCE".
8. What is the number of ways of choosing 4 cards from a pack of 52 playing cards? How many of these are face cards?
9. In how many ways can a student choose 5 subjects out of 9 available subjects, if 2 specific subjects are compulsory for every student?
10. You want to go on a trip to hill stations in Maharashtra & see all of them. There are 5000 hill stations all over Maharashtra. You can visit 365 per year. How many choices of sites do you have in your 1st year and in 2nd year? How about all the choices of sites you can visit in your first 2 years?

Annexure III
Final Test Paper # 2

DATE: 22/07/2018 **DURATION: 45 mins**

Test Paper – Permutations & Combinations

NAME:

CLASS: DIVISION: ROLL NO. CONTACT NO.

Solve the following questions.

1. How many even numbers greater than 300 can be formed with the digits 1, 2, 3, 4, 5 if repetition of digits in a number is not allowed?
2. In a class there are 40 boys & 20 girls. A teacher wants to select a class representative and an assistant class representative. In how many ways can this be done if both should not be of same gender?
3. In how many different ways the letters of the word “BOARD” can be arranged? How many of these begin with “R”? How many words with or without meaning can be formed using the letters of the word “BOARD”, taken 3 at a time?
4. In how many ways can 4 prizes be given away to 3 boys, if boy is eligible to receive all the prizes?
5. Find the number of permutations of the word “ALLAHABAD”.
6. How many chords can be drawn through 21 points on a circle?
7. In how many ways a man can invite 6 friends to a party so that two or more remain present?
8. There are 20 stations from C.S.T. to Thane. How many different types of second class monthly season tickets must be printed in order that a passenger can purchase season ticket from any one station to another?
9. You want to go on a trip to hill stations in Maharashtra & see all of them. There are 5000 hill stations all over Maharashtra. You can visit 365 per year. How many choices of sites do you have in your 1^{st} year and in 2^{nd} year? How about all the choices of sites you can visit in your first 2 years?

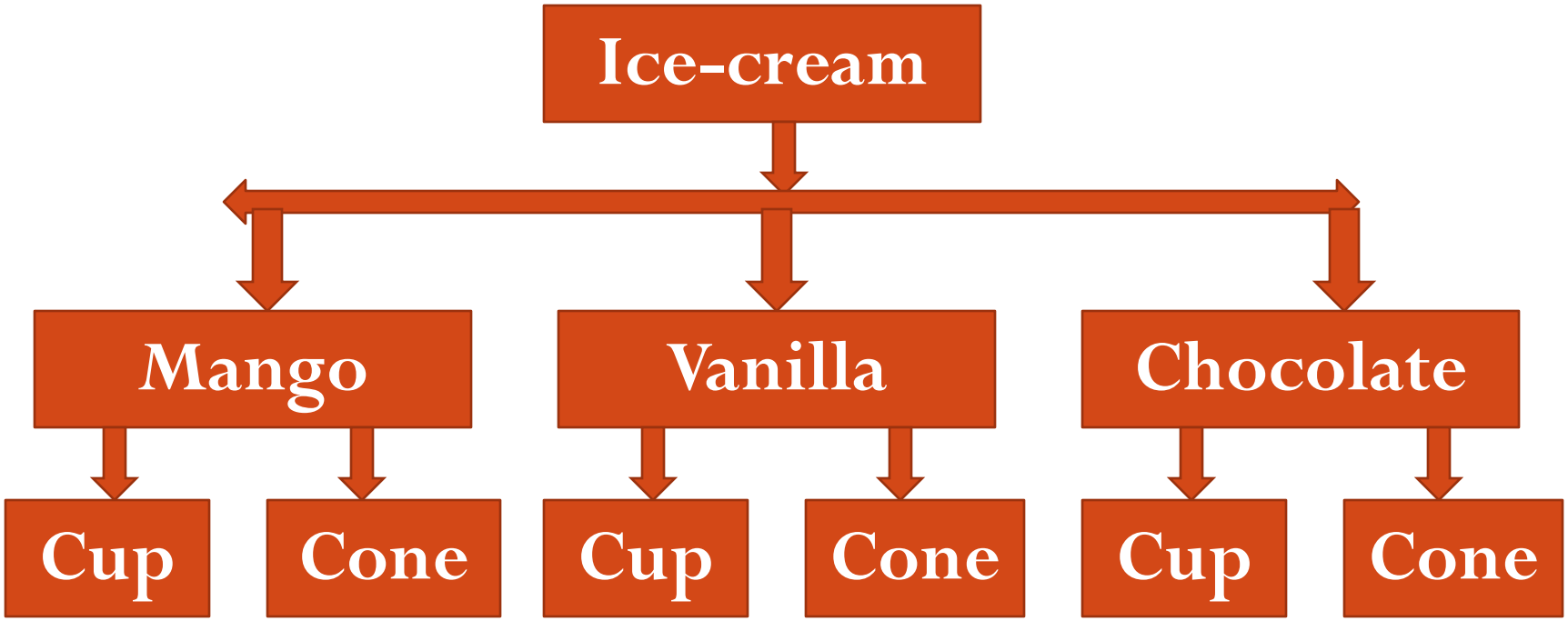
Annexure – IV

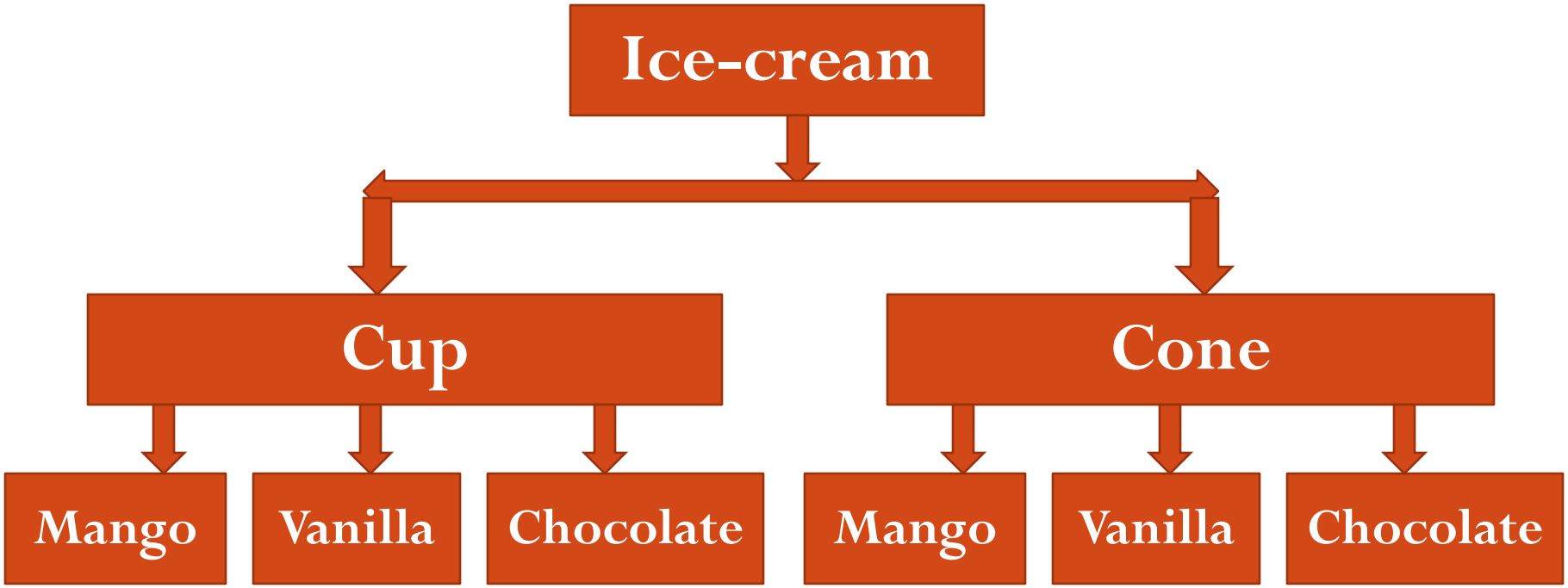
Permutation & Combination

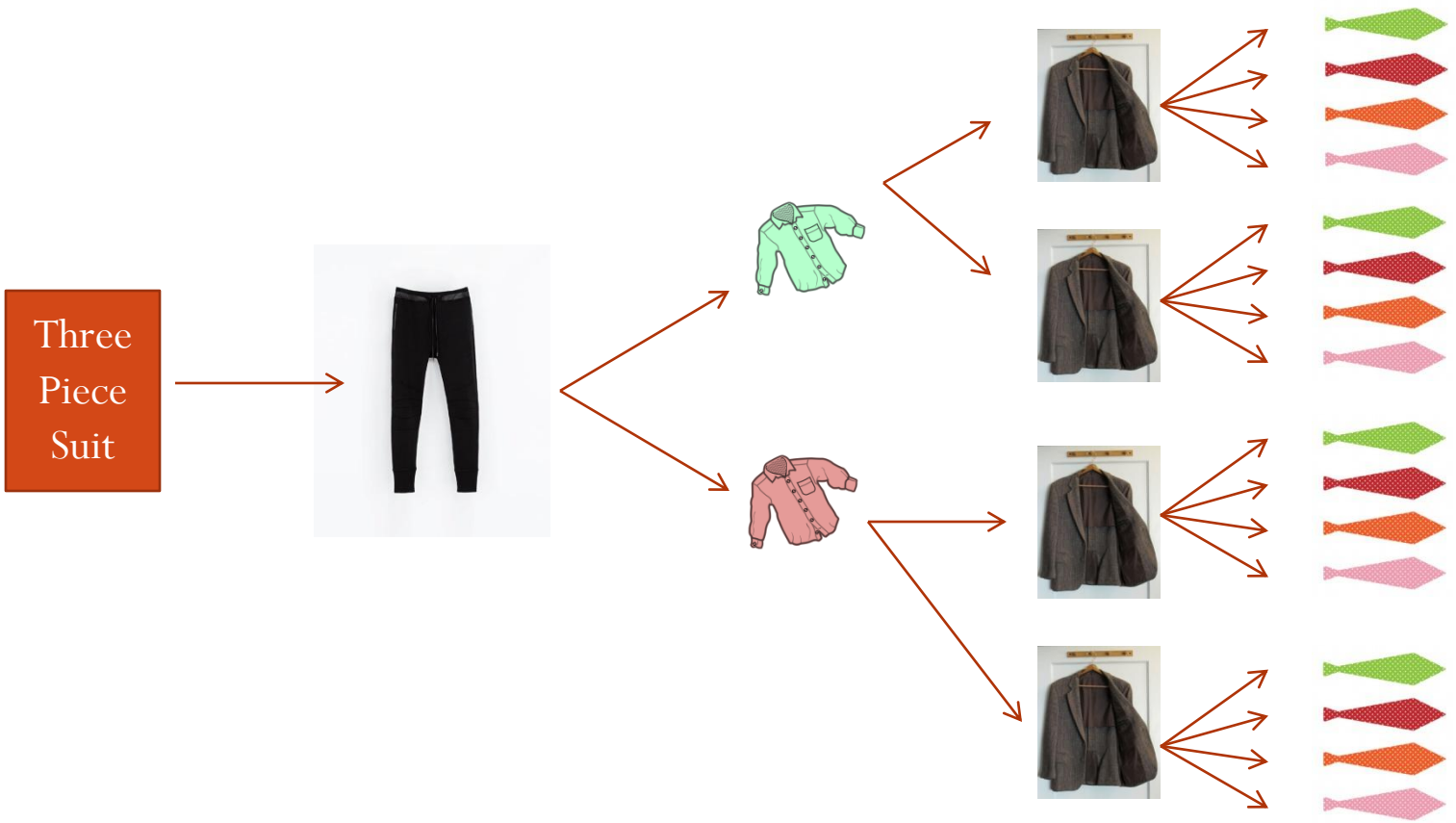
By: Shyamala Joshi

Fundamental Principle of Counting

Shyamala Joshi - July 2018


Ice-cream
Mango
Vanilla
Chocolate
Cup
Cone
Cup
Cone
Cup
Cone


Ice-cream
Cup
Cone
Mango
Vanilla
Chocolate
Mango
Vanilla
Chocolate

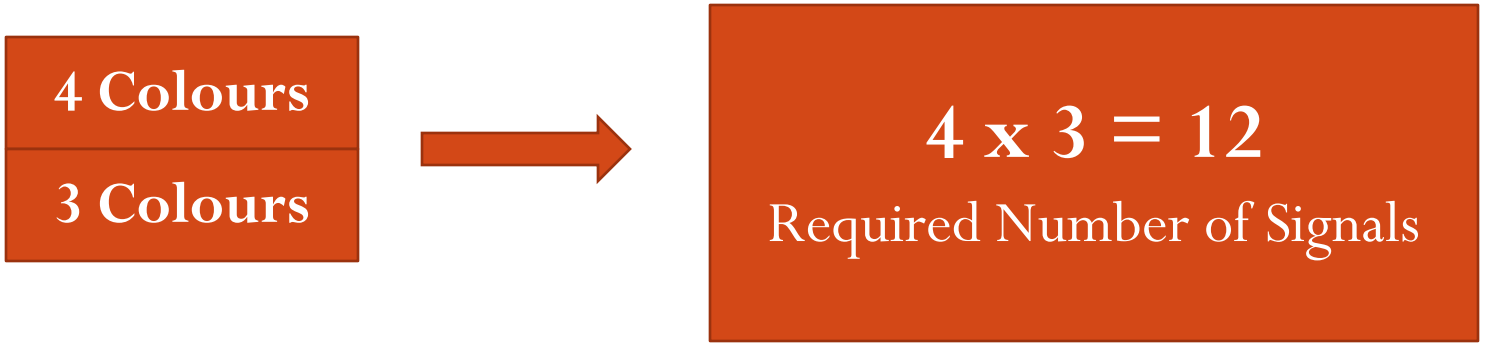

Three
Piece
Suit

Fundamental Principle of Counting

If an event can occur in “m” different ways, following which another event can occur in “n” different ways, then the total number of occurrence of the events in the given order is “m x n”.

Example # 1

- Given 4 flags of different colour, how many different signals can be generated if a signal requires 2 flags one below the other?



Example # 2

- How many 2 digit even numbers can be formed from the digits 1, 2, 3, 4, 5
  - If the digits can be repeated
  - If the digits can not be repeated

Factorial Notation

Shyamala Joshi - July 2018

Factorial Notation

The notation n! represents the product of first "n" natural numbers i.e.

$n! = 1 \times 2 \times 3 \times \ldots \times (n-1) \times n$

We define $0! = 1$

For natural number "n",

$n! = n\,(n-1)!$

$= n\,(n-1)\,(n-2)!$

… And so on

Examples

1. Evaluate 5!, 7!, 7! – 5!

2. Compute $\frac{7!}{5!}$, $\frac{12!}{10!\ 2!}$

3. If $\frac{1}{6!} + \frac{1}{7!} = \frac{x}{8!}$, find x

Permutation

Permutation is an **Arrangement** in a **definite order** of a number of objects taken some or all at a time.

$$^{n}P_{r} = \frac{n!}{(n-r)!}$$

Combination

Combination is a **Selection** of a number of objects taken some or all at a time (Order is **NOT** important)

$$^{n}C_{r} = \frac{n!}{r!\ (n-r)!}$$

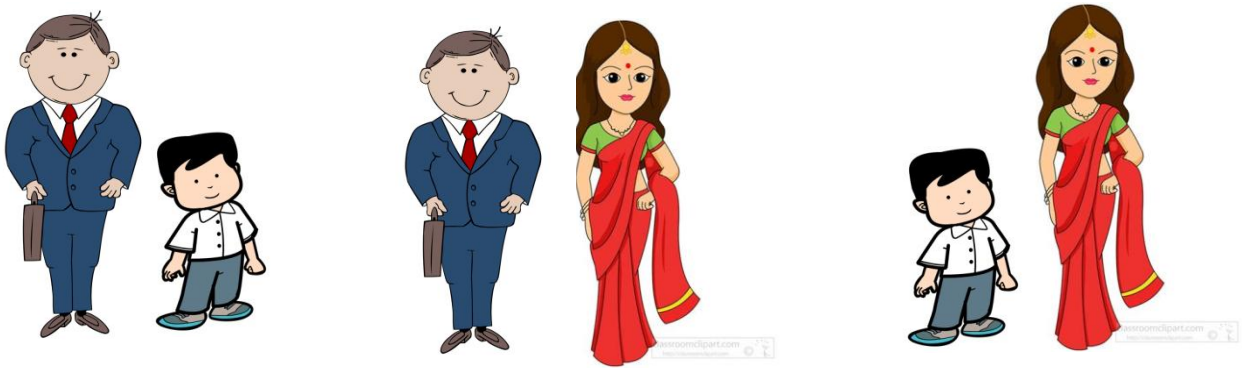
Permutation Vs Combination

- Photographs of 2 persons out of 3

Can be taken in ${}^{3}P_{2} = \frac{3!}{1!} = 6$ different ways.

Permutation Vs Combination

- Committees of 2 persons out of 3



Can be formed in ${}^{3}C_{2} = \frac{3!}{2!\,1!} = 3$ different ways.

Examples

1. 4 different books on Mathematics, 3 different books on English and 2 different books on Accounts are to be arranged in a shelf so that books on the same subjects are together. In how many different ways this can be done?
2. Find the number of arrangements that can be made from the letters of the word "D A U G H T E R"

   Also Find –

   - the number of arrangements of the same word so that all vowels are together.
   - the number of arrangements of the same word so that no vowels are together.

Result # 1

- The number of permutations of "n" different objects taken "r" at a time, when repetition of object in the permutations is allowed, is "n^r"

Example # 1

- In how many ways can 5 letters be posted in 3 post boxes, if any number of letters can be posted in all of the 3 post boxes?

First Letter can be posted in 3 post boxes in 3 ways

And

Second Letter can be posted in 3 post boxes in 3 ways

And

Third Letter can be posted in 3 post boxes in 3 ways

And

Fourth Letter can be posted in 3 post boxes in 3 ways

And

Fifth Letter can be posted in 3 post boxes in 3 ways

Therefore, **Total number of ways = 3 x 3 x 3 x 3 x 3 = 3^5 = 243**

Result # 2

- The number of permutations of "n" different objects where "p" objects are of one kind, "q" are of another kind and the rest, if any, are of different kinds is $\frac{n!}{p!\,q!}$.

Example # 2

Find a number of ways of arranging the letters of the word ROOT.

RO_1O_2T		O_1O_2RT	
RO_2O_1T	ROOT - 1	O_2O_1RT	OORT - 7
TO_1O_2R		O_1O_2TR	
TO_2O_1R	TOOR - 2	O_2O_1TR	OOTR - 8
RO_1TO_2		O_1RO_2T	
RO_2TO_1	ROTO - 3	O_2RO_1T	OROT - 9
TO_1RO_2		O_1TO_2R	
TO_2RO_1	TORO - 4	O_2TO_1R	OTOR - 10
RTO_1O_2		O_1RTO_2	
RTO_2O_1	RTOO - 5	O_2RTO_1	ORTO - 11
TRO_1O_2		O_1TRO_2	
TRO_2O_1	TROO - 6	O_2TRO_1	OTRO - 12

Required number of arrangements $= \frac{4!}{2!} = 12$


Thank
you

Annexure V
Research Schedule

Start Date of the project	22nd June 2018
End Date of the project	22nd July 2018
Total Duration of the project	1 month

The overall activity Report for the research project is as below.

Sr. No.	Activity Description	Start Date	End Date	Duration
1	Announcement of the research project and its objectives to prospective student samples	19/06/18	19/06/18	30 mins
2	Finalisation of the "Control" and "Experiment" sample group	20/06/18	20/06/18	2 hrs.
3	Setting of pilot as well as final papers including development of demonstrative teaching material	19/06/18	22/06/18	6 hrs.
4	Pilot test for both Control and Experiment Group	23/06/18	23/06/18	45 mins
5	Demonstrative teaching for Experimental Group – Lecture 1	25/06/18	25/06/18	1 hr.
6	Demonstrative teaching for Experimental Group – Lecture 2	26/06/18	26/06/18	1 hr.
7	Demonstrative teaching for Experimental Group – Lecture 3	28/06/18	28/06/18	1 hr.
8	Demonstrative teaching for Experimental Group – Lecture 4	30/06/18	30/06/18	1 hr.
9	Demonstrative teaching for Experimental Group – Lecture 5	06/07/18	06/07/18	1 hr.
10	Demonstrative teaching for Experimental Group – Lecture 6	09/07/18	09/07/18	1 hr.

11	Demonstrative teaching for Experimental Group – Lecture 7	11/07/18	11/07/18	1 hr.
12	Final test # 1 for both Control and Experiment Group	18/07/18	18/07/18	45 mins
13	Final test # 2 for only Experiment Group	22/07/18	22/07/18	45 mins
14	Paper (Pilot and Final tests) correction and scores tabulation	26/06/18	28/07/18	8 hrs.
15	Data compilation and Statistical Analysis	08/08/18	08/08/18	2.5 hrs
16	Conclusions and Report writing	03/09/18	15/10/18	20 hrs.
			Grand Total	**48 hrs. 15 mins**

Notes:

1. The project was conducted in tandem with the fulfilment of routine teaching duties and by drawing out extra time both by the researcher and sample students. Therefore, breaks and delays on account of unavoidable circumstances needed to be accommodated.
2. The Pilot Test was conducted on 23/06/2018 and the Final Test # 1 was held on 18/07/2018, thereby sufficient gap was provided to minimize the recall effect.
3. The statistical analysis was performed manually using simple calculator.

About Author

Personal Information

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College Information

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Address	:	Bhadran Nagar, Off S.V. Road Malad (West) Mumbai 400 064
Teaching since	:	1993
Subject taught	:	Mathematics & Statistics
Taught to	:	Class XI and XII - Commerce