**Heuristic Method**

The word ‘Heuristic’ has been derived from the Greek word ‘Heurisco’ which means ‘I find’ or ‘I discover’ . This method implies that the attitude of students shall be that of the discoveries and not of passive recipients of knowledge

Heuristic method of teaching science was proposed by H. E. Armstrong (1888-1928) . In words of Professor Armstrong, “Heuristic methods of teaching are methods which involve our placing students as far as possible in the altitude of the discoverer – methods which involve their finding out instead of being merely told about things”.  According to him, the real spirit of heuristic method is placing the student in the position of original investigator which means involving his ‘finding out instead of being merely told about things’.

In Heuristic method  the student be put in the place of an independent discoverer. Thus no help or guidance is provided by the teacher in this method. In this method the teacher sets a problem for the students and then stands aside while they discover the answer.

The aim of this method is to develop the scientific attitude and spirit in pupils. The spirit of enquiry prompts the pupils to learn. This method insists on truth, whose foundation is based on reason and personal experiences. As a matter of fact there is no spoon-feeding or more acceptances of facts which are given by the teacher. The object of the heuristic method is “to make pupils more exact, more truthful, observant and thoughtful to lay this solid foundation for future self-education and to encourage this growth of spirit of enquiry and research.” In this method, the teacher creates such an environment that a problem arises before the pupil. All the pupils think about the problem, observe and in the end they conclude some result. In this way, all the pupils find out truth by their own way.

**The application of heuristic knowledge**

The application of heuristic knowledge to a problem is sometimes known as heuristics. The term seems to have two usages:

1) Describing an approach to learning by trying without necessarily having an organized hypothesis or way of proving that the results proved or disproved the hypothesis. That is, “trial-by-error” learning.

2) Pertaining to the use of the general knowledge gained by experience, sometimes expressed as “using a rule of-thumb.”

**Objectives of Heuristic Strategy**

The following are the main objectives of Heuristic strategy:

To develop among students the ability of self-learning.

To develop among students the ability of critical thinking.

To develop among students the attitude of logical thinking.

To develop among students the attitude of accepting truth only after verification.

To develop among students the attitude of not accepting things based on blind faith.

To develop among students the scientific thinking.

**Principles underlying Heuristic method**

1. The principle of activity

2. The principle of logical thinking

3. The principle of proceeding from the known to the unknown.

4. The principle of purposeful experience

5. The principle of self thinking and self study

**Merits of Heurism or Heuristic Method**

The following are some merits of heuristic method—

1. In this method, pupils realize the problem, think about it, observe it, test it and conclude about it. This creates scientific attitude in pupils. Hence, this method is a scientific method of teaching.

2. This is a psychological method as the student learns by self-practice. The maxim learning by doing is involved. Students learn by doing themselves

3. In heuristic method, in addition to the mental and reasoning powers, development of self-confidence and intellectual inter-dependence etc. also occurs gradually. This prepares them to solve any problem likely to arise in future life.

4. In heuristic method, the entire task is completed in school. This solves the problems of home work automatically.

5. This method motivates pupils for doing more difficult tasks. This also avoids the hindrance of individual differences in learning.

6. In this method, pupils work themselves and consult themselves. This coordinates their physical and mental powers. It develops in the student a habit of diligence.

7. This method does not allow the pupils for cramming of ready-made knowledge. The knowledge is gained by self- activity and hence it is retained for a longer time.

8. Power of observation and reasoning and drawing inference are developed.  It creates clear understanding.

9.  It is a meaningful learning The student learns by doing so there is a little scope of forgetting. It develops self-confidence, self-discipline in the students.  The students acquire command of the subject. He has clear understanding about notions of the subject.

10.  It gives the student a sense of achievement. The methods make them exact and bring them closer to truth. It develops scientific attitudes among students by making them truthful and honest for they learn how to arrive at decisions by actual experimentations.

11.  It inculcates in the student the interest for the subject and also develops willingness in them. It develops the habit of enquiry and investigation among students .It develops habit of self- learning and self- direction.

12. It provides scope for individual attention to be paid by the establishing cordial relations between the teacher and the taught.

**Demerits of Heurism or Heuristic Method**

The following are the few demerits of heuristic method—

1. Heuristic method is useful only for the pupils of higher classes and not for lower-class pupils. This method cannot be used in nursery and primary classes.  It is not suitable for lower classes as they are not independent thinkers. Discovery of a thing needs hard work, patience, concentration, reasoning and thinking powers and creative abilities.

2. The modern culture and civilization has become so much complicated that every pupil acquire knowledge by doing research himself. The teacher has to provide its knowledge directly.

3 The knowledge of all the subjects of a curriculum cannot be imparted to the pupils for examinations by heuristic method. Hence, this method is not appropriate.

4.  It is a very long and slow process and a hence a prescribed course cannot be covered within a specific period. In searching out the knowledge by this method much time is consumed. It is a long and time consuming method and so it becomes difficult to cover the prescribed syllabus in time Hence, it is impossible to search out the knowledge as a result of pupils’ self-efforts for a period of thirty or forty minutes according to the school time-table.

5. While using this method, the teacher prepares everything before-hand which deprives the pupils of the opportunities of self-thinking. This also deprives them of the training of self-discussion.

6. It is very costly because well equipped laboratories are required for the purpose. This method is successful if well-equipped libraries, laboratories and good textbook written in heuristic lines are available. . For this method, special books, devices and trained teachers are needed.

7.  It pre-supposes a very small class and a gifted teacher and the method is too technical and scientific to be handled by an average teacher. It suits only hard working and original thinking teachers.  The method expects of the teacher a great efficiency and hard, experience and training. Presently enough teachers are not available for implementing learning by heuristic method

8.  In this method too much stress is placed on practical work which may lead a student to form a wrong idea of the nature of science as a whole. They grow up in the belief that science is some thing to be done in the laboratory, forgetting that laboratories were made for science and not science for laboratories.

9. Evaluation of learning through heuristic method can be quite tedious. The gradation of problems is a difficult task which requires sufficient skill and training.

10. Learning by this method, pupils leave school with little or no scientific appreciation of their physical environment. The students are immature and it is difficult for them to draw conclusions. The students have to spend a lot of time to find out minor results. The romance of modern scientific discovery and invention remains out of picture for them and the humanizing influence of the subject has been kept away from them.

**Lecture method**

Lecture method is most convenient and inexpensive method of teaching any subject.  Lecture method is teacher controlled and information centered approach in which teacher works as a role resource in classroom instruction. In this method, the only teacher does the talking and the student is passive listens. This method is used in order to acquire knowledge and concept. Lecture method mainly focuses on cognitive objectives. The main emphasis of this strategy is the presentation of the content.

**Principles of lecture method**

(1) A student can learn better through listening.

(2) Through lecture method, the teacher makes an attempt to impart perfect and complete knowledge of the subject or the topic students.

(3) Subject matter can be correlated with other subjects.

(4) New knowledge is given related to previous knowledge.

**When to use lecture method**

(1) It is used to give an overview of a large unit.

(2) This method is an effective way for motivating pupils and developing their interest in the subject.

(3) It is used for supplementing the pupils reading and for clarifying main concepts.

(4) This method helps to save the time of students by providing important information in short time period.

(5) This method is used to provide background.

**Steps of the lecture method**

**(1) Preparation for the lecture:-**

This includes silent points like

(a) appropriate language and manner of presentation according to the nature of students.

(b) selection of audio-visual aids and instructional materials.

(c) planning the motivational technique

(d) anticipating certain difficulties and problem during the lecture.

(e) finding suitable solution and alternatives to these barriers to a successful lecture.

**(2) Introduction to the lecture:-**

It should be done briefly and if it is executed poorly, it can initially kill off the enthusiasm of the student.

**(3) Giving the body of the lecture:-**

The teacher should have a given cognitive framework upon which he relies to achieve a more logical presentation.

**(4) Conclusion of the lecture:-**

Following technique can be used to wrap up the lecture.

(a) summarizing the major points presented.

(b) forming generalization

(c) giving implications.

**Advantage of lecture method**

(1) It is economical with regard to time.

(2) It helps in developing the habit of concentration among the students.

(3) It helps in achieving even high order cognitive objectives ( i.e ) application, analysis, synthesis.

(4) Lecture method presents the subject matter in a systematic way.

(5) It develops good audience habits.

(6) Through this method, new subject matter can easily be introduced.

(7) It enables linkage between previous knowledge with a new one.

**Disadvantages of lecture method**

(1) Since this is a teacher-centered method so it provides very little scope for student activity.

(2) Student plays a passive role in this method.

(3) Individual differences are not taken into consideration.

(4) It can not be used for achieving psycho motor objectives.

**Inductive Deductive method**

**Inductive-Deductive method:**It is a combination of two methods.

**Inductive Method:**

It leads from concrete to abstract, particular to general and from example to formula.

**Procedure:** First do lots of example, and then generalize the formula.

**Example:** Ask students to draw a few sets of parallel lines and let them measure the alternate angle.

Ask student to construct the few triangles. Let them measure the sum of the angles and draw conclusion.

**Merits of Inductive Method**

By making use of this method, following merits get accrue to the students as well as to teacher:

1. As this is a scientific method, thus it helps to considerable extent in developing scientific outlook among the students.
2. This method helps to develop scientific attitude among the students.
3. With the help of this method, teacher can develop qualities of critical thinking and habit of keen observation among the students properly and accurately.
4. This is a very logical and psychological kind of teaching science.
5. By this method, students get various opportunities to play an active role in learning process.

**Demerits of Inductive Method**

This method has certain limitations, some of which are as follows:

1. The results or conclusions drawn from such method are not found to be final in case where the amount of data is very large in number.
2. All the topics of science cannot be dealt with this method properly.
3. This method can only be used when teacher have much time for teaching process.

**Deductive method:**

Opposite of inductive method. Here, the learner proceeds from general to particular, abstract to concrete and from formula to examples.

**Procedure:**immediately after announcing the topic for the day, the teacher gives the relevant formula and solves some problem related to formula. The student understands how the formula can be used or applies. Then few problems are given to the student to solve by themselves.

**Example:** Facts like sum of the angle is 1800 and solve the problem related to given facts.

Formula like area of rectangle = Length x Breadth and solve problem related to given formula.

**Merits**

(1) This method is short and time-saving. The solution of the problems by pre-established formulas takes little time.

(2) It encourages memory as the students have to memories a considerable number of formulas.

(3) This method is advantageous at the “Practice and revision” stage.

(4) It enhances speed and efficiency in solving problems.

(5)This removes the incompleteness and inadequacy of Inductive method.

**Demerits**

(1) The beginners find it very difficult to understand an abstract formulas, if they are not acquainted with a number of concrete instances.

(2) This method will demand blind memorization of a large number of formulas. And this will cause an unnecessary and heavy burden on the brain of children.

(3) In this method, memory becomes more important than understanding and intelligence and that is educationally unsound.

(4) Blind cramming leads very often to forgetting the formulas and the children are at a loss to recollect. This ultimately leads to no learning

(5) This method is not suitable for development of thinking, reasoning and discovery.

**Conclusion**: we can conclude that inductive method is the forerunner of deductive method. The deductive method will give a good follow up, if the topic is understand through induction. thus the teaching must begin with induction and end in deduction.

**Analytic and synthetic method**

**ANALYTIC METHOD**:

It proceeds from unknown to known. ‘Analysis’ means ‘breaking up’ . In this method we **break up** the unknown problem into simpler parts and then see how these can be recombined to find the solution. So we start with what is to be found out and then think of further steps or possibilities the may connect the unknown built the known and find out the desired result.

**Example**: if  a/b=c/d, prove that ac-2b2/b=c2-2bd/d

Solution start from unknown i.e. to solve this problem we have to start from

ac-2b2/b=c2-2bd/d  and get the answer a/b=c/d

***Example:***

if a2+b2=7ab prove that 2log (a+b) = 2log3+loga+logb

**Proof:**

To prove this using analytic method, begin from the unknown.

The unknown is 2log (a+b) = 2log3+loga+logb

Now, 2log (a+b) = 2log 3+ log a+ log b is true

If log (a+b)2 = log 32+ log a + log b is true

If log (a+b)2 = log 9 + log ab is true

If log (a+b)2 = log 9ab is true

If (a+b)2 = 9ab is true

if a2+b2=7ab which is known and true

Thus if a2+b2= 7ab prove that 2log (a+b) = 2log3+loga+logb

**Merit of ANALYTIC METHOD**

* It is logical method. It leaves no doubts and convinces the learner.
* It helps student in understanding and strengthen the urge to discover facts.
* Each steps has the its reason and justification. So , no fixed steps is required.

**Drawback ANALYTIC METHOD**

* It is lengthy method
* It is difficult to acquire efficiency and speed
* It may not be applicable to all topics equally well.

**Synthetic Method**

It is opposite of analytic.

**Example**: if  a/b=c/d, prove that ac-2b2/b=c2-2bd/d

Solution start from unknown i.e. to solve this problem we have to start from a/b=c/d and get the answer ac-2b2/b=c2-2bd/d

**Merit Synthetic Method**

* It is short method, it glorify memory, it suit the teachers and it follow the same process as given in the text book.

***Demerits Synthetic Method***

* It is not a psychological method.
* There is a scope for forgetting.
* It makes the students passive listeners and encourages cramming.
* In this method confidence is generally lacking in the student.
* There is no scope of discovery.
* The recall of each step cannot be possible for every child.

**Difference between Analytic Method & Synthetic Method**

|  |  |  |
| --- | --- | --- |
| No. | **Analytic Method** | **Synthetic Method** |
| 1 | Analysis means breaking up into simpler elements. | Synthesis means building up separate element and their combination |
| 2 | It proceeds from the unknown to the known facts. | It proceeds from the known to the unknown facts. |
| 3 | It is a method of discovery. | It is a method of present­ation of discovered facts. |
| 4 | It is a process of thinking (exploration). | It is a product of thought. |
| 5 | It is lengthy and laborious. | It is short and concise. |
| 6 | It pulls apart or breaks up the statement under solution. | It puts together or synthesizes known facts. |
| 7 | It can be rediscovered. | Once forgotten, it cannot be recalled. |
| 8 | It is slow, round-about and involves trial and error. | It is quick, straight forward and does without trail and error. |
| 9 | It answers satisfactorily and question that may arise in the mind of pupil. | It does not satisfy doubts and questions arising in the mind of the leaner. |
| 10 | It is a general method; it is a method for the thinker and discoverer. | It is a special device; it is a method for the crammer. |
| 11 | The students can recall and reconstruct easily any step if forgotten. | It is not that easy to recall or reconstruct any forgotten step. |
| 12 | It develops originality. | It develops memory. |
| 13 | It is informal. | It is informal. |
| 14 | It is formational. | It is simply informational. |
| 15 | It is based on heuristic lines. | There is no heuristic approach in it. |
| 16 | It is fore-runner of synthetic. | It is the follower of analysis. |

**Conclusion**: Since analysis is a lengthy method, it needs the help of Synthesis for the removal of doubts. Synthesis is the complement of the analysis method. both the method are interdependent. Teachers should offer help for the analytic form of the solution and that synthetic work should be left for the students.

**Problem Solving method**

Maths is a subject of problem. Its teaching learning process demands solving of innumerable problems. A problem is a sort of obstruction or difficulty which has to be overcome to reach the goal. Problem solving is a set of events in which human beings was rules to achieve some goals – **Gagne.** Problem solving involves concept formation and discovery learning –**Ausubel**

**Steps in Problem Solving / Procedure for Problem solving**

1. **Identifying and defining the problem:**

The student should be able to identify and clearly define the problem. The problem that has been identified should be interesting challenging and motivating for the students to participate in exploring.

1. **Analysing the problem:**

The problem should be carefully analysed as to what is given and what is to be find out. Given facts must be identified and expressed, if necessary in symbolic form.

# 3. **Formulating tentative hypothesis**

Formulating of hypothesis means preparation of a list of possible reasons of the occurrence of the problem. Formulating of hypothesis develops thinking and reasoning powers of the child. The focus at this stage is on hypothesizing – searching for the tentative solution to the problem.

1. **Testing the hypothesis:**

Appropriate methods should be selected to test the validity of the tentative hypothesis as a solution to the problem. If it is not proved to be the solution, the students are asked to formulate alternate hypothesis and proceed.

1. **Verifying of the result or checking the result:**

No conclusion should be accepted without being properly verified. At this step the students are asked to determine their results and substantiate the expected solution. The students should be able to make generalisations and apply it to their daily life.

**Example :**

Define union of two sets. If A={2,3,5}. B={3,5,6} And C={4,6,8,9}.Prove that:  AU(BUC)=(AUB)UC

**Solution :**

**Step 1: Identifying and Defining the Problem**

After selecting and understanding the problem the child will be able to define the problem in his own words that

1. The union of two sets A and B is the set, which contains all the members of a set A and all the members of a set B.
2. The union of two set A and B is express as ‘AUB ’

The common elements are taken only once in the union of two sets

**Step 2: Analysing the Problem**

After defining the problem in his own words, the child will analyse the given problem that how the problem can be solved?

**Step 3 : Formulating Tentative Hypothesis**

After analysing the various aspects of the problem he will be able to make hypothesis that first of all he should calculate the union of sets B and C i.e. ‘BUC’ Then the union of set A and’BUC ’. Thus he can get the value of AU(BUC) . Similarly he can solve (AUB)UC

**Step 4:** **Testing Hypothesis**

Thus on the basis of given data, the child will be able to solve the problem in the following manner. In the example it is given that after solving the problem the child will analyse the result on the basis of given data and verify his hypothesis whether A U (B U C) is equals to  (A U B)  U C or not.

**Step 5 : Verifying of the result**

After testing and verifying his hypothesis the child will be able to conclude that

A U (B U C) = (A U B)  U C

Thus the child generalises the results and apply his knowledge in new situations.

# Merits

* This method is psychological and scientific in nature
* It helps in developing good study habits and reasoning powers.
* It helps to improve and apply knowledge and experience.
* This method stimulates thinking of the child
* It helps to develop the power of expression of the child.
* The child learns how to act in new situation.
* It develops group feeling while working together.
* Teachers become familiar with his pupils.
* It develops analytical, critical and generalization abilities of the child.
* This method helps in maintaining discipline in the class.

# Demerits

* This is not suitable for lower classes
* There is lack of suitable books and references for children.
* It is not economical. It is wastage of time and energy.
* Teachers find it difficult to cover the prescribed syllabus.
* To follow this method talented teacher are required.
* There is always doubt of drawing wrong conclusions.
* Mental activities are more emphasized as compared to physical activities.

**Conclusion**

Problem solving is a suitable approach in teaching of mathematics. It develops in the learners the ability to recognize analysis, solve and reflect upon the problematic difficulties.

**Project method**

The project method is based on John Dewey’s philosophy of pragmatism.

According to Dr Kilpatrick: A project is a unit of wholehearted purposeful activity, carried out in natural setting.

According to Ballard: A project is a bit of real life that has been imported in school.

Project is based on the principle of learning by doing. This method is an ideal way of promoting creativity, arousing curiosity etc.

There are two types of projects :

* Individual project: it is carried by single students.
* Group project: it is carried out by the group of students.

**PROCEDURE**: To complete any project we have to follow 5 stages

1. Providing a situation: Teacher must provide the situation to the student which may arose curiosity. Student must felt its important situation to do research on it.
2. Choosing and purposing: Teachers can give number of project but selection is done by the student. Teachers can only be a guide.
3. Planning of the project: students have to do the planning with the guide of teacher to carry out the project
4. Executing the project: In this step the teacher helps student in assigning work according to their need, interest capability etc. Each member must actively involved in executing the project.
5. Judging the project: The student along with the teacher must review the progress of the project

**Merits of Project Method**

By making use of this method, following advantages are gained by teacher and students:

* It upholds the dignity of labour.
* There is an opportunity for mutual exchange of ideas.
* As students get proper freedom to execute the project in accordance with their interest and abilities, because of which they get their psychological needs satisfied to considerable extent.
* This method is not only subject centred, but due importance is being provided to the students also. Students are permitted to choose projects on their own, as a result of which they make use of their abilities to maximum possible extent.
* Through this method, students are provided with various opportunities by which they can satisfy their interests and desires.
* Habit of critical thinking gets developed among the students through this method. Not only get this, an urge to make use of scientific methods to solve various problems also developed among the students through this method.
* With this method, students get the ample chances in which they can develop coordination among their body and mind. Through this method, teacher can lead a well balanced development of the students.
* Through this method, science teaching can be done with considerable success, as science is a practical subject and this method is also scientific and practical in nature. The selected project correlates with the real problems of life which students confront in their everyday life. Thus, they find it quite interesting to sort out such problems. Not only this, through the information gained, they become able to solve out their own life problems independently and effectively.
* This method helps in promoting social interaction and co-operation among the students, as they have to work in a group and have to interact with various persons for gathering information. As the student works with full agreement of the social needs, he gets moulded in accordance with the social needs of the society in which he lives or exists. Thus, through this method, sense of social cooperation and responsibility get developed among the students, by which they can become responsible citizens in the future.
* As students gain knowledge directly through their own efforts, thus, they acquire permanent kind of information, which is retained by them since a long period of time.
* Mostly the projects are undertaken in classroom as classroom assignments, because of which load of home work from the students get reduced to considerable extent.

**Demerits of Project Method**

This method has certain limitations, which are as follows:

* This method takes a lot of time to plan and execute a single project. As the time available with the teacher is limited in the schools, thus they find it difficult to make use of this method in their class.
* It is not possible to design different projects for different topics and it is also not possible to cover all the topics or content in a single project. Thus, this method becomes impractical in nature.
* For proper execution of a project, large number of financial resources are required, which seems difficult to arrange in our nation as we have to face shortage of resources in every sphere of life.
* Such method can only be prove successful if the teacher is highly knowledgeable, alert and exceptionally gifted. The responsibility of teacher becomes multil-folded as right from providing situations and opportunities for the selection of projection, he provides the students with all the provisions by which they can execute the project successfully.
* Systematic and adequate learning is not provided by this method, as it is a method of incidental learning. Through this method, students learn only what is required by them in relation to the completion of the projects. Thus, through this process, it is not possible to treat the curricular areas in systematic and orderly manner.
* Generally it is found that teachers do not possess much information regarding the manner in which this method should be used as a result of which they hesitate from using this method, as a result of which, it’s utility remains more or less limited to negligible extent.