# ASSESSMENT OF LEARNING STRATEGIES ADOPTED BY XI STANDARD STUDENTS IN STUDYING PLANT TAXONOMY

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## Abstract

*The science of taxonomy involves the history and study of classification and the study of different systems of classification. Taxonomy is difficult to learn". A survey method has been used for studying learning strategies used in learning taxonomy. Data collection has been done through content achievement tests with the twin objectives of analysing strategies used by students for select topics of taxonomy and for studying relationships between achievement and strategies. High achievers have been found to use meta-cognitive strategies.*

**Keywords:**
   *Assessment, Strategies, Plant Taxonomy*

## Introduction

Plant Taxonomy is the study of plants involving classification, naming and detailed descriptions of taxa. Taxon refers to a category of plants of any rank, be it a species, genus, family, order, sub-class, class, sub-division and division. Taxonomical terms and names are derived from Latin language. There are innumerable names given to the same plant and complex terms assigned to describe the various parts of the plant body. This demands too much of memorization. Recapitulation of the technical terms are also not easy. Taxonomy also involves memorization of the detailed accounts of plant taxa. Students at the higher secondary and even graduate level find this a difficult task to accomplish.

Students may adopt different strategies to learn taxonomy like any other subject matter. The term 'Strategy' derived from the ancient Greek term strategies, refers to generalizing or the art of war. Learning strategies are the thoughts or actions that students use to complete learning tasks. They are tools that students employ independently. Learning strategies take different forms. Weinstein and Mayer (1986) argue that an interest in learning strategies is the natural outgrowth of a change in orientation from behaviorist theories to cognitive theories of learning. Though there is a lot of literature available on learning strategies in different subjects/content matters, very little information is available on strategies to be used in plant taxonomy. Therefore there is an urgent need to train the teachers in understanding the learning strategies adopted by students while learning plant taxonomy. At present such training is lacking in pre-service and in-service teacher training programmes. This may be partly due to the lack of realization about the significance of learning strategies and partly due to lack of research studies in our country. This applies very much to the training of teachers in teaching taxonomy at the secondary level as well.

Learning strategies are techniques that can be used to assist in any type of learning task. Good strategy users adapt their strategies to fit the task but not all children are good strategy users. Students have to be trained in choosing and using learning strategies that will make them better learners of both language skills and content material.

Schmeck (1988) stated that strategy is "the implementation of a set of procedures (tactics) for accomplishing something" and learning strategy is "a sequence of procedures for accomplishing learning". Weinstein and Mayer (1986) proposed learning strategies as "behaviour and thoughts that a learner engages in during learning and that are intended to influence the learner's encoding process". More specifically Rigney (1978) defined learning strategies as "cognitive strategy" which is "used to signify operations and procedures that the student may use to acquire, retain and retrieve different kinds of knowledge and performance.

It is not always possible to understand the strategies employed by the students to deal with different learning tasks. Some of the strategies like 'make inferences', in which students devise meaning from content, are mental processes that are difficult to observe. Other strategies like use of graphic organizers, take notes, etc. can be easily observed and measured. The learning strategies have been classified in different ways so far. Out of these, the classification given by Weinstein and Mayer (1986) is comprehensive. Here, however, we have categorized strategies into task-based and meta-cognitive strategies.

**Figure 1: Broad general classification of strategies**

Task based strategies /Meta cognitive strategies

1. PLAN

    What you know

    Background

    Inferences

    Predications

    Personalise

    Transfer/cognate

    Substitute/paraphrase

2. MONITOR

    Your imagination

    Imagery

    Real objects

    Role play

3.  MANAGE

Organizational skills

Patterns

Group/classify

Graphic organizers

Take notes

Summarize

Selective attention

4.  EVALUATE

Variety of resources

Access information resources

Co-operate

Talk yourself through it

*The meta-cognitive strategies can be used for almost any task and are based on reflecting on one's own thinking while the task-based learning strategies are more determined by the specific nature of the task and the resources of the student.* Meta-cognitive learning strategies are general learning strategies. Reflecting upon your own thinking and learning is meta-cognitive thinking. Once students begin to think about their own learning they can begin to notice how they learn, how others learn and how they might adjust, how they learn to learn more efficiently. There are four general meta-cognitive strategies (organize or plan your own learning; manage your own learning; monitor your own learning; evaluate your own learning). These meta-cognitive strategies follow the sequential order of the process a learner generally goes through in accomplishing any task.

*The task-based learning strategies focus on how students can use their own resources to learn most effectively.* Sixteen strategies have been grouped into four categories (strategies that use what you know, strategies that use your imagination, strategies that use your organizational skills, strategies that use a variety of resources). These are strategies that are applied to language learning. Some of the strategies are

meta-cognitive strategies (viz., organize, plan, manage your own learning, monitor, evaluate, etc) and task-based strategies (viz., using background knowledge, making inferences, making predictions, personalizing, transfer/ using cognates, substitute/ using imagery, using real objects, role play, find/apply patterns, group or classify using graphic organizers / take notes, summaries, use selective attention, access information sources, co-operate, talk yourself through it.).

A number of learning and teaching strategies have been quoted (Web quests of New South Wales, Dept. of Education and Training, 2006). Some of these are active listening; jig saws; listen – think-pair– share questioning; reciprocal teaching, role-playing, rubrics, six thinking hats and Socratic dialogue.

Weinstein and Mayer (1986) argue that an interest in learning strategies is the natural outgrowth of a change in orientation from behaviourist theories to cognitive theories of learning. They present a typology of learning strategies consisting of eight categories and discuss prototypical research studies within each of the eight areas.

The mismatches between teaching and learning styles in science courses have several serious consequences (Lind Silverman, 1988). It causes development of less interest in course material and if the mismatches are extreme the students are apt to lose interest in Science altogether.

Levin *et al* (1988) asked college undergraduates to study a hierarchical plant classification system according to one of the two provided organizational strategies: a) figural taxonomy, which consisted of labeled boxes and connecting lines to represent respectively the nodes and links of the hierarchy, b) a pictorial mnemonomy in which the unfamiliar plant forms were recoded into more familiar concepts which were then thematically related to other terms on the same branch of the hierarchy. Mnemonomy students outperformed taxonomy students on (a) both immediate and 5-day delayed measures of classification system construction and use; and (b) a test that required analogies involving the plant terms – thereby adding to recent evidence that scientific mnemonic strategies can facilitate performance on tasks that require some degree of higher-order thinking.

According to Maralee Mayberry (1998) the under-representation of women (and men of colour) in science has motivated many science educators to develop innovative classroom pedagogies aimed at making science courses and curricula more attractive and inviting to all students. One dominant approach to Science Education is to transform how students learn by implementing collaborative approaches to learning in the classroom.

Felder (1993) has suggested a multistyle approach to science teaching depending on the dimensions of learning style of the student.

Stapel *et al.* (1997) advocates full integration of sheltered and shelter based strategies throughout a science methods course. These are simplifying input, providing content clues, drawing on prior background, providing opportunities for group work, the sheltered experience, co-operative learning( assigning roles to individual group members), lesson –designs, peer-teaching and student assessment.

Problem-based learning strategy has been mentioned as an effective technique in science instruction (Wang *et al.,* 1998).

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Chamot *et al.* (1999) points to the fact that learning strategies research has revealed a wealth of information on the types of strategies students use to learn. Over one hundred strategies have been identified by different learning strategies researchers. Nisbet and Schucksmith(1986) present a list of six commonly mentioned categories of strategies in literature viz., asking questions, planning, monitoring, checking, revising and self-testing.

Conner and Gunstone (2004) reported a qualitative case study investigation of the knowledge of learning strategies by 16 students in a final year high school biology class to conscious knowledge of learning. Here students were encouraged to develop evaluation of their learning skills independently through activities that promoted metacognition. The value of promoting metacognitive approaches in this context is

discussed. Some of the learning strategies, objectives and technology options currently available are illustrated are illustrated as follows (Table 1).

**Table 1: Learning strategies, their objectives and technology options**

Learning strategies objective Technology

| 1. Lecture | Know/ think /do | Power point, audio/video, multimedia |
|---|---|---|
| 2. Collaboration | Know/ think/do | Communication tools, interpersonal, group discussion (Workshops) |
| 3. Journal/reflection | Know/think/do | E-mail(assignments, readings)/internet |
| 4. Project | Know/think/do | Power point/projects and presentation |
| 5. Self-directed | Know/think/do | Power point/multimedia/video/web page/ workshops, online libraries and course ware |

Teaching strategies can be summarized as follows:

- Teaching strategies in terms of methodology
- Modeling
- Multiple intelligence
- Discovery
- Traditional culture
- Mind mapping
- Co-operative
- Games
- Socratic dialogue
- Brain-storming
- Field-work
- Simulations
- Collaborative
- Inquiry
- …….no name methodology?

Taxonomy is taught only in XI Std. and the overall performance in Biology has not improved over the years. This has been attributed to lack of learning strategies in Biology. Being a faculty of Botany was realization enough that subjects like Taxonomy have their own learning strategies. It was decided therefore to look into taxonomy curriculum and relate it to learning strategies and IQ.

**Methodology**

Three families viz. Solanaceae, Fabaceae and Liliaceae have been listed out in the DMS Biology Textbook of XI Standard (NCERT, 2006). The families have been described technically with relevant illustrations and details. However, the strategies to be used for the study of these families have not been mentioned anywhere!

An attempt was made first to list out the strategies to be used based on the part to be studied. Over and above this a list of 90 strategies used for taxonomical studies was listed out arbitrarily through discussions.

**Table 2: List of strategies**

Strategies used by 11th standard students in learning taxonomy as per achievement test conducted on 18/02/09.

| | | Strategies | Levels of thinking |
|---|---|---|---|
| TBS | 1. | using key words/ relating key words | K |
| TBS | 2. | mnemonics | A |
| MCS | 3. | reading and recollection. | K |
| MCS | 4. | recollecting and recall | K |
| MCS | 5. | trial and error | S |
| TBS | 6. | visual imagery | K |
| TBS | 7. | practical skills | S |
| MCS | 8. | common sense and logic | A |
| MCS | 9. | judgement | A |
| MCS | 10. | logical relations | U |
| MCS | 11. | meaningful elaboration | U |
| MCS | 12. | summarizing while reading | U |
| MCS | 13. | paraphrasing major ideas | U |
| MCS | 14. | relating ideas | U |
| MCS | 15. | imagery and recollection | U |
| MCS | 16. | periodic reviews | K |
| MCS | 17. | analogies | U |
| MCS | 18. | categorizing knowledge | U |

| | | |
|---|---|---|
| TBS | 19. utilizing information | A |
| TBS | 20. abbreviation | K |
| MCS | 21. logic | U |
| MCS | 22. analysis &understanding | A |
| TBS | 23. visual stimulus | K |
| MCS | 24. instinct, guesswork | A |
| TBS | 25. taking notes | K |
| TBS | 26. selecting main ideas | K |
| TBS | 27. picturising the examples | K |
| TBS | 28. using mental images to relate words | S |

| | Strategies | Levels of thinking |
|---|---|---|
| MCS | 29. interpretation and processing | A |
| MCS | 30. common sense | A |
| TBS | 31. utilizing information | A |
| TBS | 32. processing and synthesizing information | U |
| TBS | 33. associating previously learned item images | K |
| MCS | 34. observing | S |
| TBS | 35. dissecting | S |
| MCS | 36. understanding | U |
| TBS | 37. looking at common patterns | S |
| MCS | 38. analyzing important ideas | U |
| TBS | 39. loud reading | K |
| TBS | 40. monitoring what is learnt | K |
| MCS | 41. looking for logical relationships | U |
| MCS | 42. inferring conclusion based on previous knowledge | A |
| MCS | 43. mental picturising | S |
| MCS | 44. committing to memory | K |
| MCS | 45. thinking about the ideas | U |
| MCS | 46. understanding and treating anxiety | D |
| TBS | 47. relating contents to think | U |
| TBS | 48. summarising the material | U |
| MCS | 49. interpretation | A |
| MCS | 50. analysis of important ideas relating words | A |
| TBS | 51. retrieving information | K |
| MCS | 52. discussion with others | U |
| MCS | 53. memorizing strategy | K |
| TBS | 54. summarizing what is learnt | K |
| MCS | 55. reinforce what is learnt | K |
| TBS | 56. reading the material over several times | K |
| MCS | 57. relating key words to ideas | U |
| TBS | 58. practising drawing again and again | S |
| TBS | 59. creating an outline | S |
| TBS | 60. drawing pictures and cartoons relating to the material | S |

| | | |
|---|---|---|
| TBS | 61. drawing pictures | S |
| MCS | 62. self-study | K |
| TBS | 63. related to the theme | U |
| TBS | 64. related to the experience | U |
| MCS | 65. trial and error method | S |
| MCS | 66. retention | K |
| MCS | 67. self-monitoring | A |
| MCS | 68. self-questioning | A |
| MCS | 69. self-punishment | A |
| MCS | 70. self-rewards | A |
| TBS | 71. summarizing section-wise | U |

| | Strategies | Levels of thinking |
|---|---|---|
| TBS | 72. summarizing paragraph | U |
| TBS | 73. usage of acronyms | K |
| MCS | 74. a combination of SQ3R strategy | A |
| MCS | 75. elaboration | U |
| MCS | 76. asking questions | U |
| TBS | 77. writing several times | K |
| MCS | 78. free associate | U |
| TBS | 79. summarise | U |
| TBS | 80. guess-work | K |
| MCS | 81. interrelating items should be learnt creatively | A |
| TBS | 82. illustrating with suitable diagrams | U |
| TBS | 83. selecting characters | U |
| TBS | 84. relating key-words and concepts | U |
| TBS | 85. relating key-points | U |
| MCS | 86. time management | S |
| MCS | 87. summarizing from newspaper | A |
| TBS | 88. field study | A |
| TBS | 89. practising diagrams several times | S |
| TBS | 90. observing carefully given material | S |

MCS – Meta-cognitive strategy; TBS – Task based strategy

An achievement test tool was prepared for assessing learning levels in Taxonomy of XI Std. DMS students for maximum marks of 80. The questions belonged to four different categories of Knowledge, Application, Understanding and Skill and were restricted to the three families – Solanaceae, Liliaceae and Fabaceae. Weightage was given to the questions depending on the levels. A list of 51 questions were prepared with levels (K, S, U, A) and weightage options given in the questions was restricted to the

content. Wherever other options out of the syllabus are mentioned, it was due to constraint of content limit. Repetitions came about because of incorporation of more content questions from a limited content in order to ensure proper evaluation.. An answer key also was incorporated alongside. (See Achievement test Module and answer key).

The achievement test tool was administered to DMS XI Standard students for a period of 2 hours in the Botany Lab of RIE, Mysore. The requisite plant material belonging to the three families were provided to enable them to arrive at an appropriate answer through the usage of appropriate learning strategies (ref Table 2 for list of strategies).

The achievement test administered to the class XI students consisted of 51 items belonging to 3 families viz. Liliaceae, Solanaceae and Fabaceae and belonged to knowledge, understanding, application and skill levels of learning (ref Table 3 for Achievement Test). Marks were allotted according to the learning levels. The test was administered to the students for 2 hours in Botany Lab, RIE, Mysore. The requisite and available plant materials were procured and provided to facilitate usage of different learning strategies.

**Table 3: Achievement Test for Learning levels in Taxonomy of XI Std DMS students**
                        **(Final Questionnaire)**

Date: 25.3.2009
         Time: 2 hours
Name of the student:
         Name of the teacher:
Max. Marks: 80
         Marks Obtained:

**Family: Fabaceae**

| Sl. No. | Question | Levels | Weightage | Learning strategies used |
|---------|----------|--------|-----------|--------------------------|
| 1 | What was the earlier name of the family Fabaceae?<br>a. Leguminosae<br>b. Umbelliferae<br>c. Magnolidae<br>d. None of the above | K | 1 | |
| 2 | What are the sub-families of family | K | 1 | |

| | | | | |
|---|---|---|---|---|
| | Fabaceae?<br>a. Malvaceae, Asclepiadaceae, Tiliaceae<br>b. Sterculiaceae, Arecaceae, Convolvulaceae<br>c. Papilionaeae, Caesalpiniaceae, Mimosae<br>d. Liliaceae, Asteraceae, Cannaceae | | | |
| 3 | Root nodules are found in the family<br>a. Liliaceae<br>b. Solanaceae<br>c. Fabaceae<br>d. None of the above | K | 1 | |
| 4 | Pulvinous leaf base is the characteristic feature of the family<br>a. Liliaceae<br>b. Solanaceae<br>c. Fabaceae<br>d. None of the above | K | 1 | |
| 5 | Differentiate between Pinnately compound and Palmately compound leaves. | U | 1 | |
| 6 | What do you mean by Placentation? | U | 1 | |
| 7 | Differentiate between Racemose and Cymose inflorescence. | U | 1 | |
| 8 | Differentiate between Marginal and Axile Placentation | U | 1 | |
| 9 | What are root nodules and how do they help the leguminous plants? | U | 1 | |
| 10 | Write the floral diagram of Fabaceae. | S | 1+1 | |
| 11 | Represent the Vexillary aestivation of the family Fabaceae. | S | 1+1 | |
| 12 | Draw the L S of ovary of *Delonix regia.* | S | 1+1 | |
| 13 | Define hypogynous flower. Draw a neat sketch of hypogynous ovary. | S | 1+2 | |
| 14 | Draw a figure showing diadelphous condition. | S | 1+1 | |
| 15 | What is the botanical name of Sunhemp and for what purpose it is used? | A | 1+1 | |
| 16 | Which family does Muliathi belong to? What purpose is it used for? | A | 1+1 | |
| 17 | How are the members of the family Fabaceae helpful to mankind? | A | 1+1 | |

**Family: Solanaceae**

| Sl. No. | Question | Levels | Weightage | Learning strategies used |
|---|---|---|---|---|
| 18 | What is the common name of the family Solanaceae?<br>a. Tomato family<br>b. Petunia family<br>c. Potato family<br>d. None of these | K | 1 | |
| 19 | Underground storage stems are found in the family<br>a. Fabaceae<br>b. Liliaceae<br>c. Solanaceae<br>d. None of these | K | 1 | |
| 20 | Tobacco belongs to which family?<br>a. Liliaceae<br>b. Solanaceae<br>c. Fabaceae<br>d. None of these | K | 1 | |
| 21 | Chilli which is also used as medicine belongs to the family.<br>a. Liliaceae<br>b. Fabaceae<br>c. Both (a) and (b)<br>d. Solanaceae | K | 1 | |
| 22 | Define aestivation? Mention the different types of aestivation. | U | 1 | |
| 23 | Differentiate between Epipetalous & Epiphyllous stamens. | U | 1 | |
| 24 | Differentiate between Apocarpous and Syncarpous ovary. | U | 1 | |
| 25 | Which is the alkaloid present in tobacco and to which family does it belong to? | U | 1 | |
| 26 | Write the floral diagram and floral formula of the family Solanaceae. | S | 1+3 | |
| 27 | Write the diagram for axile | S | 1+1 | |

| | | | | |
|---|---|---|---|---|
| | placentation | | | |
| 28 | Draw L.S of the flower of *Cestrum nocturnum* (Solanaceae). | S | 1+1 | |
| 29 | Draw T.S. of bicarpellary superior ovary with axile placentation. (T.S. of ovary of *Cestrum nocturnum*) | S | 1+1 | |
| 30 | Which family does Ashwagandha belong to? Write the uses of Ashwagandha. | A | 1+1 | |
| 31 | What are the ornamentals from Solanaceae you would grow in your garden? | A | 1 +1 | |
| 32 | List out the other uses of family Solanaceae. | A | 1+2 | |

**Family: Liliaceae**

| Sl. No. | Question | Levels | Weightage | Learning strategies used |
|---|---|---|---|---|
| 33 | Which of the following families are included under Monocot families? <br> a. Solanaceae <br> b. Fabaceae <br> c. Liliaceae <br> d. All the above | K | 1 | |
| 34 | What is the common name of the family "Liliaceae"? <br> a. Potato family <br> b. Lily family <br> c. Pea family <br> d. None of these | K | 1 | |
| 35 | *Aloe vera* belongs to which family <br> a. Fabaceae <br> b. Liliaceae <br> c. Solanaceae <br> d. None of these | K | 1 | |
| 36 | Underground bulbs, are found in the family. <br> a. Liliaceae <br> b. Solanaceae | K | 1 | |

| | | | | |
|---|---|---|---|---|
| | c. Fabaceae<br>d. None of these | | | |
| 37 | Which is the alkaloid extracted from *Colchicum autumnale?*<br>a. Nicotine<br>b. Colchicine<br>c. Both(a) and (b)<br>d. None of these | K | 1 | |
| 38 | Define Venation? Differentiate between reticulate and parallel venation. | U | 1 | |
| 39 | Define Perianth. | U | 1 | |
| 40 | Differentiate between monocotyledonous and dicotyledonous plants. | U | 1 | |
| 41 | Why *Aloe vera* is classified under xerophytic plants? | A | 1 | |
| 42 | Write the floral diagram and floral formula of the family Liliaceae. | S | 1+3 | |
| 43 | Draw a neat sketch of placentation in family Liliaceae. | S | 1+1 | |
| 44 | Draw L.S of the flower of Liliaceae. | S | 1+1 | |
| 45 | Draw a neat diagram of T.S. of ovary of Liliaceae. | S | 1+1 | |
| 46 | Draw a neat sketch of epipetalous stamen. | S | 1+1 | |
| 47 | Draw a neat sketch of monocotyledonous seeds. | S | 1+1 | |
| 48 | What are the uses of colchicine *?* | A | 1+1 | |
| 49 | What are the uses of *Asparagus* and *Allium?* | A | 1+1 | |
| 50 | Which plant of Liliaceae is used for cytological studies? | A | 1 | |
| 51 | Which plant of Liliaceae with leaf tendril is used as an ornamental plant ? | A | 1 | |

* Due to constraint of content limit, other options which are out of the syllabus are mentioned. (Q. Nos. 1, 2, 15, 25, 27, 43, 45, 48). Repetitions came about as for proper evaluation more questions had to be incorporated from a limited content.

**Results and Discussion**

Table 4 gives an idea of the analysis of techniques used by the students to learn taxonomy. The strategies of recall and visual imagery are the highest employed strategies being used by 47% and 31% of the students respectively. The strategies of using key words, trial and error method, recall, summarizing and taking notes have been used 30-40% of the times. The moderately employed learning strategies were mnemonics, practical skills, picturising examples, using mental images, interpretation and processing, understanding, analyzing important ideas, loud reading, memorizing strategy, reinforcement of what is learnt, practising, drawing again and again, creating outline, drawing pictures and cartoons and relating content to theme.

Eleven of the 23 strategies listed out here are task-based strategies and are not of higher order where as nine are meta-cognitive strategies (cf. list of strategies, Table 2).
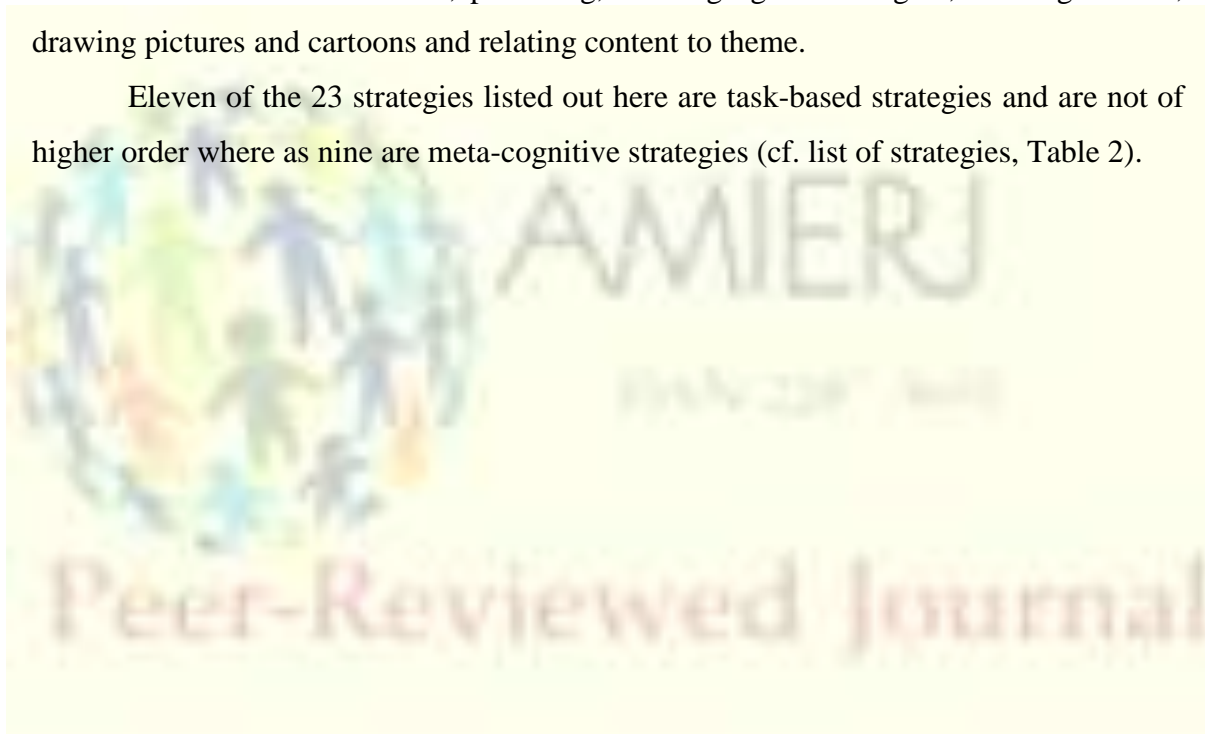
**Table 4: Analysis of learning strategies in plant taxonomy used by students of DMS XI Standard**

| Name of the student | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Low achievers** | | | | | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |
| Ibosama morajcha | | | | | | | | | | | | | | | | | | | | | | | | | ✓ | ✓ | | | | | ✓ | | | | |
| Raghav.p. | ✓ | ✓ | | ✓ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aparna | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Moderate achievers.** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Deep kiran kaur | | | | | | ✓ | ✓ | | | | | | | | | | | | | | | | | | ✓ | | | | | | | | | | |
| Ajay rao | | | | ✓ | ☐ | ☐ | | | | | | ✓ | | | | | | | | | | | | | ✓ | | | | | ✓ | | | | | |
| Abhishek kulshreshtha | | | | ✓ | | | ✓ | ✓ | | | | ✓ | | | | | | | | | | | | | ✓ | ☐ | ☐ | ☐ | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ |
| Soumya mahesh | ✓ | | | ✓ | | | | | | | | ✓ | ✓ | | | | | | | | | | | | ☐ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Shilpa Nanjappa | ✓ | ✓ | | ✓ | | | | | | | | ✓ | | | | | | | | | | | ✓ | | ✓ | ☐ | ☐ | ☐ | ☐ | ✓ | | | ☐ | ☐ | |
| Kiuldeep kumar | ✓ | | ✓ | | | | | | | | | | | | | ✓ | | | | | | | | | | | ✓ | | | | | | | | |
| Promod nandan | | | | | | | | | | | ✓ | ✓ | | | | | | | | | | | | | | ☐ | ✓ | | | | | | | | |
| Shuthi.S.Y | | | ✓ | | | | | | | | | | | | | | | | | | | | | | ✓ | ✓ | | ✓ | | | | | | | |
| Bhuvan.P | | | | | ✓ | ✓ | | | | | | | | | | | | | | | | | | | | | | | ✓ | | ✓ | | | | |
| Rajas.M.R | | | | | ✓ | ☐ | | | | | | ✓ | | | | | | | | | | | | ✓ | | | | | | | | | | | |
| Bharath.R.S | | | | | ✓ | ✓ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rakshith.R | | | | ✓ | | ✓ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **High achievers** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Vishaka Garg. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | ✓ | ✓ | ✓ | | | | ✓ | | ✓ | ✓ | | | | ✓ | | | | ✓ | | | | |
| Nidhi.C.shekar | ✓ | ✓ | | | | | | | | | | | | | | | | | | | | | | | | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | |
| Shashwat awasthi | | | | ✓ | ✓ | ✓ | | | | | | | | | | | | | | | | | | | ✓ | | | | | | | | | | |
| Mahathi | | | | ✓ | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | | | | | |

| Name of the student | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Low achievers** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ibosama morajcha | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Raghav.p. | | | | | | | | | | | | | | | | ✓ | ✓ | | | | ✓ | ✓ | | | | | | ✓ | | | | | | | |
| Aparna | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Moderate achievers.** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Deep kiran kaur | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | | | | | | | | | |
| Ajay rao | | | | | | | | | ✓ | | | | | | | | | | | | ✓ | | | | | | | ✓ | | | | | | | |
| Abhishek kulshreshtha | □ | □ | □ | □ | □ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Soumya mahesh | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | | | | | | | | | | ✓ | | | | | | | | | | | | | |
| Shilpa Nanjappa | | | □ | | | | □ | | ✓ | | | | | | | □ | | | | | ✓ | | ✓ | | | | | ✓ | | | | | ✓ | | |
| Kiuldeep kumar | | | | | | | | ✓ | | | | | | | | | ✓ | ✓ | | | | | | | | | | | | | | | | | |
| Promod nandan | | | | ✓ | | | | | | | | □ | | | | | | | | □ | | | | | | | | | | | | | | | |
| Shuthi.S.Y | ✓ | | ✓ | ✓ | | | | | | | | ✓ | | | | | | | | ✓ | | | | | | | | | | | | | | | |
| Bhuvan.P | ✓ | | | | | | | | ✓ | | | ✓ | | | | | ✓ | | | ✓ | | | | | ✓ | | ✓ | | | | | | | | |
| Rajas.M.R | | | | ✓ | | | | | | | | | | | | | | | | ✓ | | ✓ | | | ✓ | | ✓ | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bharath.R.S | | | | | | | | | | | | ✓ | | | | | | | | □ | ✓ | □ | | | ✓ | | | | | | | | | | |
| Rakshith.R | | | | | | | | | | | | | | | | | | | | | ✓ | ✓ | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **High achievers** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Vishaka Garg. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nidhi.C.shekar | | | ✓ | | | | ✓ | | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | | |
| Shashwat awasthi | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mahathi | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | | | | | | | | | |

**Table 5** gives an idea of percent use of learning strategies by different categories of achievers. Recollecting and recall, taking notes and reading the material over several times are strategies that are used maximum and there are common place strategies in a subject like taxonomy – all 3 being knowledge – level based strategies and not that of higher levels of thinking. Recollecting and recall are metacognitive strategies (of a higher order) when compared with taking notes and reading the material over several times which are task-based strategies.

Discussion with others is an understanding level strategy and visual imagery is a knowledge-level strategy and these have been used moderately. The former strategy is meta-cognitive strategy and the latter a task-based strategy.

Using key words / relating key words (K-.level)(1-tbs);Practical skills (S level) (7-tbs); Picturising the examples (K level)(27-tbs);Using mental images to relate words (S level)(28-tbs); Common sense (A level)(30-mls); Utilising information (A level)(31tbs); Committing to memory (K level)(44mcs); Paraphrasing major ideas (Understanding level)(13-mcs);. Reinforcing what is learnt (Knowledge levels)(51-mcs); Summarise (Understanding level) (79-mcs) are strategies which are used to an even-lesser extent i.e. for less moderate use. Strategies 1, 27, 44 and 55 are knowledge level strategies; 30 and 31 are application level strategies, 13 and 79 are skill level strategies. Out of the ten strategies which are used here five are meta-cognitive and five are task-based strategies.

However, it is clear from this account that it is knowledge level learning strategies which are used more than application and skill level strategies by the DMS XI standard students in learning taxonomy.

**Table 5a: Percentage analysis of learning strategies used by different categories of achievers in XI Standard**

| Sl.No. | Strategies used by low achievers | Frequencies of the strategies used | Percentage of the strategies |
|---|---|---|---|
| 1 | Summarise the material | 10 | 20% |
| 2 | Inter relating creativity items to be learnt | | |
| 3 | Discussion with other people | 6 | 12% |
| 4 | Summarise by paragraph | 5 | 10% |
| 5 | Utilizing information | 6 | 12% |
| 6 | Mnemonic elaboration | 2 | 4% |
| 7 | Summarised by title | 6 | 12% |
| 8 | Selecting main ideas | 2 | 4% |
| 9 | Relating key points | 5 | 10% |
| 10 | Time management | 1 | 2% |
| 11 | Recalling and dissection | 1 | 2% |
| 12 | Read the material over several times | 4 | 8% |
| 13 | Guess work | 6 | 12% |
| 14 | Common sense | 4 | 8% |

**Table 5b: Percentage analysis of learning strategies used by different categories of achievers of DMS XI Std**

| Sl.No. | Strategies used by high achievers | Frequencies of the strategies used | Percentage of the strategies |
|---|---|---|---|
| 1 | Key word | 5 | 10% |
| 2 | Mnemonics | 4 | 8% |
| 3 | Reading | 4 | 8% |
| 4 | Visual imagery | 3 | 6% |
| 5 | Mental recollection | 10 | 20% |
| 6 | Trial and error method | 3 | 6% |
| 7 | Common sense | 7 | 14% |
| 8 | Recollection | 9 | 18% |
| 9 | Practical skills | 1 | 2% |
| 10 | Judgement and logical thinking | 1 | 2% |
| 11 | Imagory and recollection | 1 | 2% |
| 12 | Periodic reviews | 1 | 2% |
| 13 | Categorising knowledge learnt | 1 | 2% |
| 14 | Abbreviations | 2 | 4% |
| 15 | Read it | 3 | 6% |
| 16 | Common sense and instinct | 4 | 8% |
| 17 | Read the material over several times | 7 | 14% |

| 18 | Recall | 47 | 94% |
|---|---|---|---|
| 19 | Take notes | 39 | 78% |
| 20 | Picture the example | 3 | 6% |
| 21 | Relate to the key words | 8 | 16% |
| 22 | Using mental Images to words | 7 | 14% |
| 23 | Committing to memory | 5 | 10% |
| 24 | Utilising information | 2 | 4% |
| 25 | Selecting the main ideas | 2 | 4% |
| 26 | Made notes | 3 | 6% |
| 27 | Practical skills | 19 | 38% |
| 28 | Summarise the material | 3 | 6% |

**Table 5c: Percentage analysis of learning strategies used by different categories of achievers of DMS XI Std**

| Sl.No. | Strategies used by moderate achievers | frequencies of the strategies used | Percentage of the strategies |
|---|---|---|---|
| 1 | Read the material over several times | 25 | 50% |
| 2 | Discussion with other people | 23 | 46% |
| 3 | Recall | 20 | 40% |
| 4 | Visual images | 23 | 46% |
| 5 | Picture the example | 9 | 18% |
| 6 | Relate key words | 7 | 14% |
| 7 | Select the main ideas | 5 | 10% |
| 8 | Memorizing | 5 | 10% |
| 9 | Mnemonic elaboration | 2 | 4% |
| 10 | Utilising information | 11 | 22% |
| 11 | Use of visual imagery | 26 | 52% |
| 12 | Selecting the characteristics of the material and differentiating between them | 1 | 2% |
| 13 | Mental imagery | 2 | 4% |
| 14 | Interpretation processing and synthesising information | 3 | 6% |
| 15 | Practising diagrams several times | 3 | 6% |
| 16 | Observation of the given material several times | 1 | 2% |
| 17 | Analysis of important ideas | 1 | 2% |
| 18 | Relate to acquire the previous knowledge | 1 | 2% |
| 19 | Retrieving information | 1 | 2% |
| 20 | Committing to memory | 6 | 12% |
| 21 | Reinforce what you have already learnt | 10 | 20% |
| 22 | Listing the characteristics of main terms | 1 | 2% |

| 23 | Work for common sense or logical relationships in the material | 1 | 2% |
|----|----------------------------------------------------------------|-----|------|
| 24 | Infer conclusions based on previous knowledge | 1 | 2% |
| 25 | Using mental images to relate words | 3 | 6% |
| 26 | Periodic reviews | 3 | 6% |
| 27 | Observe, referring the external materials other than the syllabus in the textbook | 1 | 2% |
| 28 | Understanding and treating anxiety | 1 | 2% |
| 29 | Paraphrasing major ideas | 1 | 2% |
| 30 | Understanding and relating | 1 | 2% |
| 31 | Relate the content to the theme | 2 | 4% |
| 32 | Take notes and made notes | 26 | 52% |
| 33 | Associating previously learnt items | 2 | 4% |
| 34 | Made notes of the picture | 1 | 2% |
| 35 | Observe dissect and understanding | 1 | 2% |
| 36 | Looking at the common pattern | 1 | 2% |
| 37 | Monitoring what is already learnt | 3 | 6% |
| 38 | Drawing cartoons | 2 | 4% |
| 39 | Retention | 2 | 4% |
| 40 | Re reading and analysis of input ideas | 2 | 4% |
| 41 | Self monitoring | 3 | 6% |
| 42 | Questioning main ideas | 1 | 2% |
| 43 | Create outline | 1 | 2% |
| 44 | Self rewards | 3 | 6% |
| 45 | Self study | 5 | 10% |
| 46 | General understanding | 2 | 4% |
| 47 | Loud reading | 1 | 2% |
| 48 | Use of acronyms | 1 | 2% |
| 49 | SQ3R technique | 2 | 4% |
| 50 | Asking questions | 1 | 2% |
| 51 | Writing several times | 3 | 6% |
| 52 | Relating it to experience | 1 | 2% |
| 53 | Guess work | 3 | 6% |
| 54 | Summarise | 12 | 24% |
| 55 | Reinforcement | 12 | 24% |

Table 5 a, b, c give us an idea of percentage – frequency of different strategies (strategies 1–90) used to improve retention of taxonomic information. The data have been categorized into strategies used by low, high and moderate achievers.

Moderate achievers read the material over several times (tbs), use visual imagery (tbs) and discuss with others (mcs), utilize information (tbs), observe (mcs), referring the external materials other than the syllabus in the textbooks (tbs), take notes and make notes (tbs)and associate previously learnt items (tbs), summarise (mcs) and reinforce (mcs). It is seen that moderate achievers follow both meta-cognitive as well as task-based strategies (28/55 i.e. more than 50% strategies are meta-cognitive). In contrast to this low achievers use less of meta-cognitive strategies (5/14) and more of task based strategies. High achievers however use 50% meta-cognitive strategies (14/28).

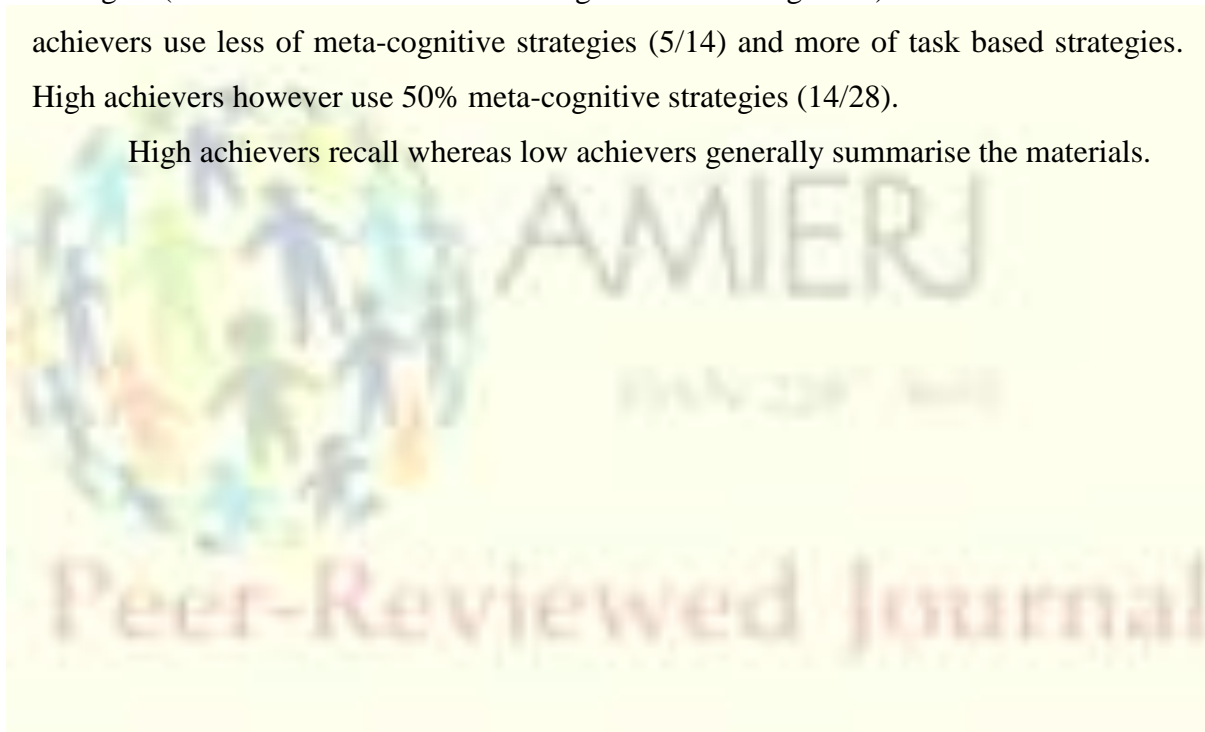High achievers recall whereas low achievers generally summarise the materials.

**Table 6: Effectiveness of concept mapping in learning taxonomy**

| Sl.No. | | | Drawing strategies | | | | | | Achievement scores | | | SPM scores | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 58 | 59 | 60 | 61 | 82 | | | | | | | | | |
| 1 | LA | | | | | | ✓ | | 36 | | | 48 | | | | |
| 2 | MA | | | | | | | | 48.5 | | | 57 | | | | |
| 3 | MA | | | | | ✓ | | | 48 | | | 57 | | | | |
| 4 | MA | | | | | ✓ | | | 43.5 | | | 54 | | | | |
| 5 | MA | | | ✓ | | | | | 44.5g | | | 54 | | | | |
| 6 | MA | | | | | | ✓ | | 61 | | | 39 | | | | |
| 7 | MA | | | | | | ✓ | | 56.5 | | | 53 | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| **\*\*\*\* strategies** | | | | | | | | | | | | | | | | |
| **58-practising drawing again and again** | | | | | | | | | | | | | Correlations | | | |
| **59- creating outline** | | | | | | | | | | | | | | | | |
| **60-drawing pictures and cartoons relating to the material** | | | | | | | | | | | | | VAR00001 | | Pearson Correlation | |
| **61-drawing pictures** | | | | | | | | | | | | | | | Sig. (2-tailed) | |
| **82-illustrating with suitable diagram** | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| **INFERENCES** | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | 1 | **Out of 19 students only 5 students have used the drawing strategy.** | | | | | | | | | | | | | | |
| | 2 | **Only 1 low achiever and 4 moderate achievers have used the drawing strategy** | | | | | | | | | | | | | | |
| | 3 | **None of the high achievers have used the drawing strategy** | | | | | | | | | | | | | | |
| | 4. | **MA: Moderate Achiever, LA: Low Achiever** | | | | | | | | | | | | | | |

Table 6 gives an idea of the effectiveness of concept mapping (or drawings) in learning taxonomy. These are strategies 58, 59, 60, 61 and 62 in strategy list of Table 6 (These are practising drawing again and again(tbs); creating outline(tbs);drawing pictures and cartoons relating to the material(tbs); drawing pictures(tbs); illustrating with suitable diagrams(tbs). Out of fifteen students only five have used mapping strategies. Only four moderate and one low achiever has used drawing / mapping strategy as is evident from achievement and IQ scores. None of the high achievers have used mapping strategy. High achievers are seen to use a higher number of metacognitive strategies when compared to moderate achievers. It is suggested therefore that field study, bringing the plant to class, employing and using a plant collector, maintaining a herbarium, dissecting a flower using hand lens, maintenance of kitchen garden, assigning garden plots for maintenance could be inculcated in students. Mnemonics should be practised as follows. For example, for remembering parts of a papillionaceous corolla of Fabaceae, the key characters of Zygomorphic, Papillionaceous corolla, Monocarpellary ovary and Monadelphous stamens, Legume fruit could be abbreviated into $ZPM_2L$ (Zilla Panchayat Member 2 Local).

**Conclusions**

The analysis also reveals that task -based strategies are more frequently used by all categories of achievers (low, moderate and high) for the study of taxonomy. An analysis based on learning levels reveals that knowledge level learning strategies are used more than application and skill level strategies by the DMS XI Standard students in learning taxonomy. Taxonomy in Botany is a discipline involving a lot of drawing/mapping strategies. However, none of the high achievers have used mapping strategies. High achievers are seen to use a higher number of meta-cognitive strategies when compared to moderate achievers. It would be worthwhile to include the list of strategies in Table 2 to evolve a learning strategy curriculum in taxon.

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