# IMPROVING THE HIGHER-ORDER THINKING SKILLS OF MIDDLE-SCHOOL STUDENTS USING ACTIVE LEARNING PEDAGOGY

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*The focus of our study is to improve the higher-order thinking skills in middle-school students by exposing them to active learning methodology and an increasing number of higher-order thinking questions. The preliminary results of this longitudinal study show an improvement in the quality of discussions and questions posed by students in sessions, suggesting an enhancement of higher-order thinking skills, as a result of exposure to active learning methodology.*

## INTRODUCTION

While most teachers would agree that the purpose of schooling is not just to enable students to recall facts and statements, but also to be able to apply that knowledge to real-life scenarios, schools rarely ensure that students are equipped with the skills to do so. These skills, which come under the bracket of higher-order thinking skills (HOTS), are essential for a school curriculum in order to create individuals who, in school as well as outside, think critically, analyse situations objectively and make rational judgements. HOTS is a concept which is prescribed by various learning taxonomies like Bloom's and SOLO (Chan, C. C., Tsui, M. S., Chan, M. Y., & Hong, J. H., 2002), and is widely regarded as referring to the cognitive abilities that enable one to apply, analyse, evaluate and create (Bloom, 1956; Krathwohl & Anderson, 2009).

Despite its significance, many schools find the concept of higher-order thinking ambiguous, and specifically, find it challenging to help students develop it. Miri, David and Uri (2007) suggest that "*the design and implementation of teaching strategies that enhance higher-order thinking among students are not a simple endeavor; they challenge even the most expert teachers.*" Both healthy classroom discussions and the freedom to explore are necessary in order to not only gain an in-depth understanding of science, but also to develop a critical bent of mind in individuals.

From our observations, a large number of formal schools still employ the expository method to teach science in classrooms. Firstly, this method results in a one-way interaction between teacher and student, with little or no scope for students to voice their opinions or doubts. Secondly, it does not allow for students to explore scientific concepts or experiment with ideas, and mainly reinforces students' lower-order thinking skills.

Active learning, however, involves the active participation of students in the learning process, not only passively listening to the teacher (Bonwell & Eison, 1991). As Meyers and Jones (1993) indicate,

> "active learning provides opportunities for students to talk and listen, read, write, and reflect as they approach course content through problem-solving exercises, informal small groups, simulations, case studies, role playing, and other activities—all of which require students to apply what they are learning."

The purpose of our intervention was to observe if active learning pedagogy improved students' higher-order thinking skills.

The diagnostic tools used by the authors in evaluating changes in students' HOTS were based on the Revised Bloom's Taxonomy (Krathwohl & Anderson, 2009). Two main indicators were identified:

a. Quality and correctness of answers given by students to higher order thinking questions asked in their assessment (which were mapped to various levels of Revised Bloom's Taxonomy), and
b. Quality of classroom discussions and student questions.

Therefore, in light of the discussion above, the authors, through this study, aim to observe if active learning methodology causes an improvement in the higher-order thinking skills of students.

## METHODS

### Study sample

A total of 40 students studying in Class 6 at a school in Bengaluru, affiliated to the CBSE curriculum, were involved in the study. The students were segregated into two sections (A & B) of 20 students each by the school at random, prior to the study. Students of both sections were taught science concepts through active learning methods that included hands-on activities and experiments. These were designed by the authors in consultation with peers and colleagues from their organization. This project began on 21 May 2018, and is still underway. This study does not have a control group as it is a longitudinal study to observe changes in students' HOT skills over a period of time.

### Session timings

The chosen school allocated 240 minutes for Science for each section, per week. In order to facilitate the following: (i) in-class activities, (ii) leading questions to be asked in class, (iii) self-reflection, and (iv) elaborate discussions and deliberations by students, the intervention took place in block sessions that lasted for 80 minutes each on Mondays, Wednesdays and Saturdays.

### Preparations for the sessions

The topics chosen for the year included the 16 chapters developed for Class 6 by the National Council of Educational Research and Training (henceforth, NCERT), and a few additional topics chosen by the authors. Each topic was developed in the form of learning modules. The learning objectives of each chapter of NCERT were written down, and modules were developed such that the learning objectives of the NCERT chapters were achieved. The modules included active learning techniques, such as activities, experiments, demonstrations, leading questions and explanations. The authors planned the order of these topics in a logical manner. Once the modules for each topic had been finalised, along with the lesson plan, the facilitators presented demonstrations to their colleagues, who provided useful feedback to be considered for the sessions in the school. The demonstrations were conducted by simulating a classroom environment as far as possible.

**Facilitation**

The authors of this study were the facilitators who devised teaching-learning methods modeled on active learning pedagogy. One facilitator acted as the main facilitator who was responsible for facilitating a science topic using active learning methods. Two other facilitators acted as observers, who noted down the questions that students asked during a session. They also noted down class attendance, student participation in class discussions, student interaction with their team members and also gave critical feedback to the main facilitator after a session.

**Pedagogy**

At the beginning of each month, the 20 students of each section were divided into 5 groups of 4 students each, consisting of both boys and girls. Each student in a group was assigned one of these roles: Materials Manager, Record Keeper, Leader and Spokesperson, to ensure that all students handled responsibility and also participated actively during activities or group discussions. Groups were formed each month based on these roles, to ensure that all students held each role at least once.

In order to implement active learning pedagogy in our sessions, the implementation process for each module consisted of the following steps:

1. A *Pretest* was provided to each student at the beginning of a new topic, to gauge the preconceptions and misconceptions, if any, about the topic and also to test some of the prerequisites that the students needed for the module.
2. After the pretest, wherever necessary, students were prodded to recall the topics dealt with in the previous session(s). In cases where the topics required specific prerequisite knowledge, it was ensured that the students learnt the prerequisite material adequately before proceeding with the modules.
3. The introduction to the module was through one or a combination of the following: visual aids (videos, pictures), oral explanation and demonstration activities wherever necessary.
4. *Activity Sheets* were provided for each topic to the students. These activity sheets contained leading questions about their day-to-day observations, instructions for activities, space to note down their observations and conclusions from the activities and leading questions to get to a conclusion about a concept.
5. This was then usually followed by a set of activities, oral explanations, or detailed discussions, or all three, catering to the learning objectives of that topic. Students were continuously encouraged to read through the instructions and perform each activity prescribed in the activity sheet by themselves, although they could take the help of their group members. All the activities were followed by a consolidation, during which the objective of that activity was made clear to the students.
6. At the end of a topic, students were made to draw a mind-map related to the topic (refer Figure 1). Mind-mapping is known to be a powerful tool to facilitate better recall of the concepts related to a topic (Buzan & Buzan, 1993). Mind-map also helps the facilitator to get a clear picture of student's state of understanding and creativity of the topic.
7. Each topic was followed by a short quiz (called Check Yourself), designed to -
   a. help students and facilitators evaluate the level of student's understanding of the topic, and introduce and expose students to questions that assessed their higher-order thinking skills.

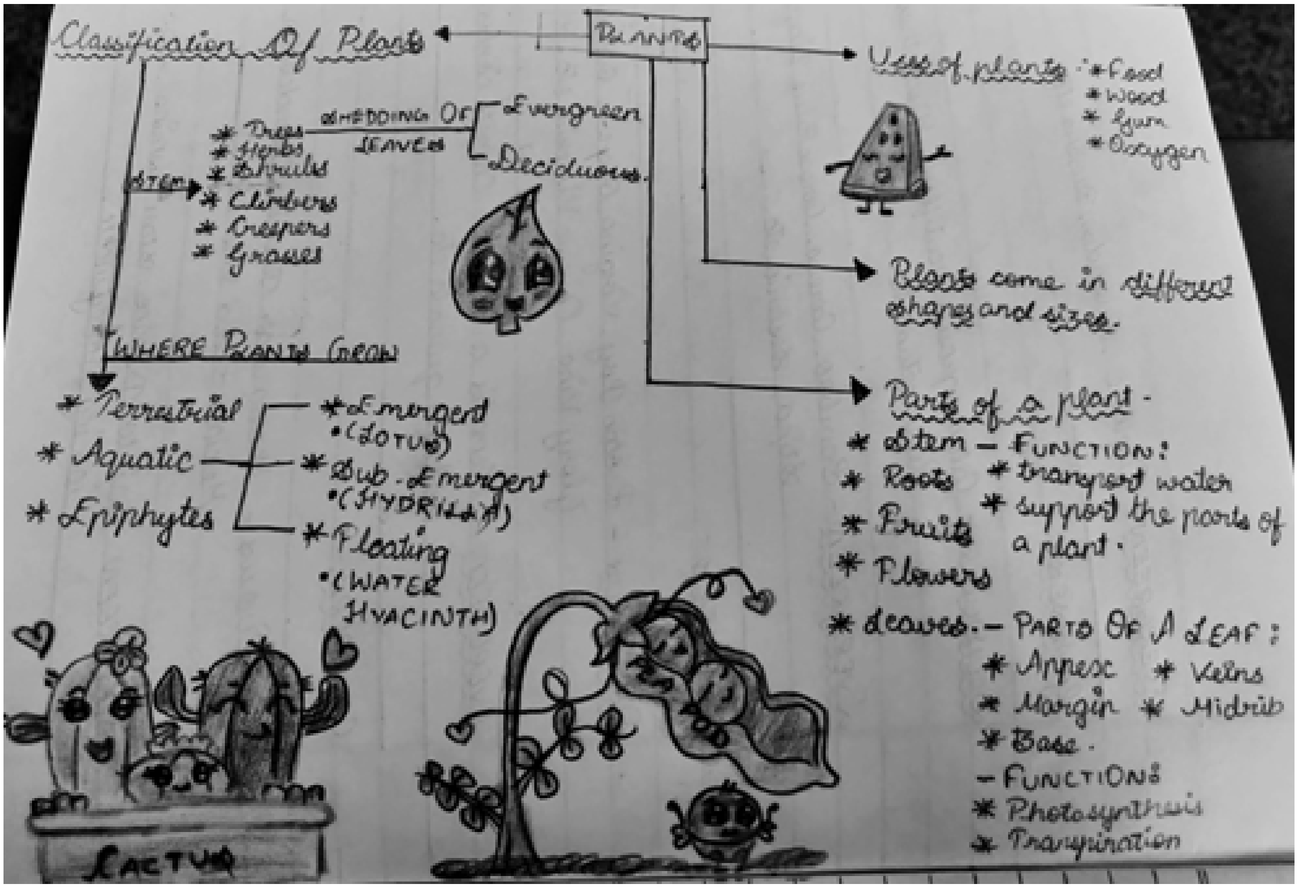


**Figure 1:** A Mindmap on the lesson 'Plants' done by student M

Along with these, students also underwent formative and summative assessment, took part in in-class quizzes, group discussions and debates, answered worksheets which had HOT questions, watched educational videos and documentaries, delivered presentations on chosen topics and participated in innovative revision games.

**Evaluation Methods (HOTS Assessment)**

Students underwent periodic assessment in the form of formative and summative assessments. Formative Assessment was given in two forms -

1. Each topic, on completion, was followed by a short quiz (check yourself), consisting of a set of five questions. This quiz was not graded.
2. Students also attended monthly Unit Tests (prescribed by the school), which were scored out of 25 marks, which, apart from accomplishing the goals of the quiz, tested what students learnt in that particular month.

Summative Assessment was given in two forms, both prescribed by the school -

1. A mid-term examination was conducted halfway into the academic year, including the topics covered in

the first half of the year.

2. A final examination was conducted at the end of the academic year, consisting of the second half's portions.

All the questions asked in the formative and summative assessments were mapped to the cognitive levels of Revised Bloom's Taxonomy. The assessment consisted of a range of questions, varying from the lowest (remember, understand) to the highest (apply, analyse, evaluate, create) levels of Revised Bloom's Taxonomy, which were either chosen from standard questionnaires or designed by the authors themselves. The assessments also consisted of different types of questions, including multiple-type questions, fill-in-the-blank questions and short-answer and long-answer questions.

Students' answers to these questions were primary indicators of the outcome of our intervention. Each successive assessment had an increasing number of HOTS questions, and was intended to (i) test students' grasp of the topic, (ii) expose them to higher-order thinking questions, and (iii) observe significant changes in their HOT skills, if any.

## RESULTS

The authors feel that, since this is a longitudinal study, one year's data would be insufficient to draw any significant conclusions about the effect of active learning on students' HOT skills. However, preliminary results show that, in the first year of this study, students showed an improvement in the quality of discussions and questions asked in class.

Presented below are a few case studies highlighting the improvements in HOTS that were observed in students during the course of our intervention, in the form of student answers to HOTS questions and in-class questions posed by students during sessions.

### Case Study 1: *Student answer to a HOTS question*

In the mid-term examination, student **IS** was able to produce an appreciable answer to a HOT question belonging to the cognitive level of **'analyse'**. The question is as follows -
*'Cobalt chloride is a chemical which is pink in colour when wet and blue in colour when dry. Using this information,*

*A) Write the procedure for an experiment to observe transpiration in plants.*
*(Materials available: A plant, cobalt chloride paper, clips)*

*B) What are your expected results?*

*C) Give a reason for your expected result.'*

**IS**'s answer is as follows:

> *"First make a solution [of] Cobalt chloride and mix it [with] water. Take a beaker and pour the solution [in]to it. Then keep the plant and cut the stem into half and put it [in]to the water [and] leave*

*it. Then after take a polythene bag. The plant that you kept in the cobalt chloride should be taken out. The leaves had to [be tied] inside tie the polythene bag. Place the plant in the sunlight [and] observe if the pink color water drops are there."*

**Observations:** IS's answer reflected her HOTS, and provided the authors an insight into the thinking processes that went into producing the answer. IS was able to use her reasoning ability and creativity. In this case, IS has combined two experiments. Although the expected answer from students was an experiment to verify transpiration by attaching the cobalt chloride paper to the leaf, she demonstrated her remarkable ability to connect two concepts and use the outcome of the other experiment as a procedure here.

**Case Study 2: *Student answer to a HOTS question***

In the final examination, student **PK** was able to give an explanation to a HOT question belonging to the cognitive level of **'apply'**. The question is as follows -
*'Sania set up an experiment. She recorded her findings in Table 1* (See Figure 2). *Which question among A, B or C was Sania testing? (Choose the most suitable question)*
*A. How many paper clips can you pick up with a magnet?*
*B. How many trials are needed to pick up the most paper clips?*
*C. Does the strength of magnetism increase if more magnets are used?'*

| | No. of paper clips picked up | | |
|---|---|---|---|
| No. of magnets | Trial 1 | Trial 2 | Trial 3 |
| 1 | 8 | 9 | 7 |
| 2 | 13 | 16 | 14 |
| 3 | 22 | 23 | 24 |

**Figure 2**

**PK**'s answer is as follows -

*Option C. Yes, the strength of magnetism increases if more magnets are used. [When] the strength of the magnetism increase[s] if more magnets are used. The power of magnetism gets stronger and can attract the most number of clips.*

**Observations**: Although the question did not expect for an explanation for their answer, PK provided an accurate explanation. The idea that the strength of magnetism increases when there are more number of magnets has been well described. The clarity in the explanation shows PK's reasoning abilities and application skills.

**Case Study 3: In-class Questions: *questions posed by students in sessions***

***30.11.2018, Friday***
**Main facilitator**: SD
**Questions:**
- Student RA: Why can't microbes decompose inorganic things?; Is compost & manure same?
- Student M: What is the substance used to make plastic?; If we add plastic to manure, will there be any disturbance for composting?; If we add seeds to compost, will it grow or become compost?

- Student V: Do vegetables and fruit peels take the same time to decompose?
- Student K: Is the amount of compost generated the same as the amount of waste thrown?

**Case Study 4: In-class Questions:** ***questions posed by students in sessions***

***29.09.2018, Monday***
**Main facilitator**: SR

**Questions:**

- Student RG: 'What holds the organs in place? Why don't they fall down?'
- Student S: 'Why do they say sit straight else we'll become a hunchback?'
- Student S: 'What is backbone and spinal cord?'
- Student RA: 'Why is the bone white and not red?'
- Student RA: 'Why do we need sternum?'
- Student M: 'What happens if bone becomes red and bone marrow is white?'
- Student M: 'Why do we only have 24 vertebrae?'
- Student K: 'How is Ca deposited in the bone?'
- Student AT: 'Cartilage is like a glue'
- Student AM: 'Who invented the X-Ray?'
- Student MG: 'Who discovered Skeleton?' ;
- Student H: 'Early man used to eat meat no?'
- Student RW: 'What would happen if we didn't have backbone?' ; Everyone else: 'We couldn't stand up straight' ; RW: 'Then why do cockroaches not stand up straight'

## DISCUSSION

This study looks at active learning methodology as a means to improve the HOT skills of middle-school students. We expect that subsequent years of exposure to active learning methodology would increase the quality of classroom discussions, the questions asked in class and the number of HOT questions answered correctly in assessments, indicating an overall enhancement of the students' HOT skills.

The authors have described below a few methods to enhance students:

### Improving Reading Comprehension

One revelation that the authors came across while facilitating was that students' English reading comprehension and communication abilities directly affected their performances in the assessments. The authors predict that improving students' English reading comprehension abilities would significantly change the way a student in the Indian context engages with the reading material provided to them.

### Practising higher-order thinking

Although students were given short quizzes at the end of every topic, it was observed that students needed to be given more practice in higher-order thinking. As Willingham (2009) suggests, tasks that are more complex tend to seem less difficult to interpret when practiced. A gradual increase in exposure to HOT questions, with instructional scaffolding wherever necessary to help students transition from simple to complex questions, and activities that make students analyse, apply and make judgements, would trigger a significant shift in their ability to answer HOT questions, and subsequently, their HOT skills.

## CONCLUSION

At the time of submission of this paper, further work on this study is ongoing. Although it is too early to draw conclusions from the data, there are some results that show that students subjected to active learning methods have shown a positive shift in their HOTS as observed during discussions, classroom interactions and answer assessment questions. In further years, we aim to continue student exposure to active learning in order to observe its effect on their HOTS.

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## REFERENCES

Bloom, B. S. (1956). Taxonomy of educational objectives. Vol. 1: Cognitive domain. *New York: McKay*, 20-24.

Bonwell, C. C., & Eison, J. A. (1991). Active Learning: Creating Excitement in the Classroom. ERIC Digest.

Buzan, T., & Buzan, B. (1993). The Mind Map Book How to Use Radiant Thinking to Maximise Your Brain's Untapped Potential. *New York: Plume*

Chan, C. C., Tsui, M. S., Chan, M. Y., & Hong, J. H. (2002). Applying the structure of the observed learning outcomes (SOLO) taxonomy on student's learning outcomes: An empirical study. *Assessment & Evaluation in Higher Education*, *27*(6), 511-527.

Krathwohl, D. R., & Anderson, L. W. (2009). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

Meyers, C., & Jones, T. B. (1993). *Promoting Active Learning. Strategies for the College Classroom*. Jossey-Bass Inc., Publishers, 350 Sansome Street, San Francisco, CA 94104.

Miri, B., David, B. C., & Uri, Z. (2007). Purposely teaching for the promotion of higher-order thinking skills: A case of critical thinking. *Research in science education*, *37*(4), 353-369.

Willingham, D. T. (2009). *Why don't students like school?: A cognitive scientist answers questions about how the mind works and what it means for the classroom*. John Wiley & Sons